

U.S. DEPARTMENT OF COMMERCE  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
NATIONAL WEATHER SERVICE  
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 303

Skill of Medium Range Forecast Group

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This is an unreviewed manuscript, primarily intended for informal exchange of information among NMC staff members.

PURPOSE

This paper depicts in a graphical manner the skill of the Medium Range (3-10 day) Forecast Group (MRFG) man and machine (numerical model guidance) forecasts. It will be updated each February in order to present the latest scores for each of the several forecast categories in the MRFG. Only scores with at least a 5-year period of record are presented. This paper contains the standardized and unstandardized mean sea-level pressure and 500-mb correlation; the Gilman, Hughes and experimental precipitation skill; the minimum/maximum absolute temperature error; and the 5-day mean normalized 500-mb correlation, temperature, and precipitation skill scores.

## Numerical Model Guidance (Past to Present)

### 1. Acronyms

- a. Baro - Reed Barotropic Advection Model Hemispheric
- b. 6L PE - 6-layer Primitive Equation Model Hemispheric
- c. CM - Course Mesh 380km FM - Fine Mesh 190km
- d. SMG26 - Spectral Model Global 24 modes 6-layers
- e. SMH2C - Spectral Model Hemispheric 24 modes 12-layers
- f. SMG3C - Spectral Model Global 30 modes 12-layers
- g. SMG4C - Spectral Model Global 40 modes 12-layers

### 2. 00Z Guidance

#### a. To 84-hours

- (1) From 1970 through 1977: 6L PE CM
- (2) From 1978 through 1979: 7L PE FM
- (3) From January 1980 to August 15, 1980: 7L PE FM to 60-hours then 7L PE CM with Fourth Order Differencing to 84-hours.
- (4) From August 15, 1980, to April 15, 1981: SMG3C to 48-hours then SMH2C to 84-hours
- (5) From April 15, 1981, through October 19, 1983: SMG3C to 48-hours then SMG2C to 84-hours.
- (6) From October 19, 1983, through December 1984: SMG4C

#### b. Greater than 84-hours to 144-hours

- (1) From 1970 through 1979: Baro (Mesh 1977-1979)
- (2) From January 1980 to August 15, 1980: 7L PE CM with Fourth Order Differencing.
- (3) From August 15, 1980 to April 15, 1981: SMH2C
- (4) From April 15, 1981, through April 1982: SMG26
- (5) From May 1982 through October 19, 1983: SMG2C
- (6) From October 19, 1983 through December 1984: SMG4C

#### c. Greater than 144-hours to 252 hours

- (1) From November 1977 through April 1981: Baro Mesh
- (2) From December 1977 through April 15, 1981: 3L PE CM
- (3) From April 15, 1981 through October 19, 1983: SMG26 to 192 hours then SMH2C to 240 hours.
- (4) From October 19, 1983 through December 1984: SMG4C to 240 hours.

### 3. 12Z Guidance

#### a. To 60-hours

- (1) From 1970 through 1977: 6L PE CM

#### b. Greater than 60-hours to 96-hours (500mb only):

- (1) From 1970 through 1977: Baro (Mesh in 1977)

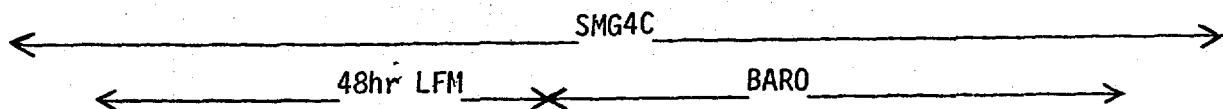
## c. To 48-hours

- (1) From October 1971 through August 1977: 7L PE FM (old LFM)  
 (2) From September 1977 through 1984: 7L PE LFM (127km)

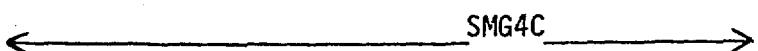
## d. Greater than 48-hours to 120 hours (500mb only)

- (1) From 1978 through 1984: Baro run from the 48-hour LFM inserted into the 60-hour SMG4C from 00Z.

Forecast Day	Day 1	Day 2	Day 3	Day 4	Day 5
12Z 00Z	12Z 00Z	12Z 00Z	12Z 00Z	12Z 00Z	12Z 00Z
12hrs 00Z	36hrs 00Z	60hrs 00Z	84hrs 00Z	108hrs 00Z	132hrs 00Z



Day 6	Day 7	Day 8	Day 9	Day 10
12Z 00Z	12Z 00Z	12Z 00Z	12Z 00Z	12Z 00Z
156hrs 00Z	180hrs 00Z	204hrs 00Z	228hrs 00Z	252hrs 00Z



\*NOTE OI ANALYSIS REPLACED THE HUF IN LATE JULY 1984.

### Figures

Figure 1 depicts the North American (NA 130 grid points) and the United States (US 86 grid points) subset mean sea level pressure (MSLP) and 500 mb correlation score verification areas.

Figure 2 is a plot of the calendar year 1984 monthly mean standardized correlation scores for the man and NMC/NWP model North American area mean sea-level pressure progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 3 is a plot of the 17/15 year (1968/70-1984) average monthly mean standardized correlation scores for the man and NMC/NWP model North American area mean sea-level pressure progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 4 is a plot of the 1968/70 through 1984 calendar year standardized correlation scores for the man and NMC/NWP model North American area mean sea-level pressure progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 5 is similar to figure 2 except the score is unstandardized.

Figure 6 is similar to figure 3 except the average is for 8 years and the score is unstandardized.

Figure 7 is similar to figure 4 except the calendar years are 1977 through 1984 and the score is unstandardized.

Figure 8 is a plot of the calendar year 1984 monthly mean standardized correlation scores for the NMC/NWP model North American area 500-mb progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 9 is a plot of the 15 year (1970-1984) average monthly mean standardized correlation scores for the NMC/NWP model North American area 500-mb progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 10 is a plot of the 1970 through 1984 calendar year standardized correlation scores for the NMC/NWP model North American area 500-mb progs

verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 11 is similar to figure 2 except the area is the United States.

Figure 12 is similar to figure 3 except the average is for 9 years and the area is the United States.

Figure 13 is similar to figure 4 except the calendar years are 1976 through 1984 and the area is the United States.

Figure 14 is similar to figure 5 except the area is the United States.

Figure 15 is similar to figure 6 except the area is the United States.

Figure 16 is similar to figure 7 except the area is the United States.

Figure 17 is similar to figure 8 except the area is the United States.

Figure 18 is similar to figure 9 except the average is for 10 years and the area is the United States.

Figure 19 is similar to figure 10 except the calendar years are 1975 through 1984 and the area is the United States.

Figure 20 is a plot of the calendar year 1984 monthly mean standardized correlation scores for the man, NMC/NWP model, European Center for Medium Range Weather Forecasting (ECMWF), and Linear Regression (LR - see NMC ON 259 of June 82) North American area 500-mb mean progs verifying 6 to 10 days after forecast day.

Figure 21 is a plot of the 6 year (1979-1984) average monthly mean standardized correlation scores for the man and NMC/NWP model North American area 500-mb progs verifying 6 to 10 days after forecast day.

Figure 22 is a plot of the 1979 through 1984 calendar year standardized correlation scores for the man, NMC/NWP model and ECMWF (1982-1984) North American area 500-mb mean progs verifying 6 to 10 days after forecast day.

Figure 23 depicts the 41 stations in the United States where the temperature forecasts are verified.

Figure 24(a,b,c) is a plot of the calendar year 1984 bi-monthly mean absolute error minimum temperature scores for the man, Klein Lewis (KL) objective, and climatology temperature forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 25(a,b,c) is a plot of the 14 year (1971-1984) average bi-monthly mean absolute error minimum temperature scores for the man, KL, and climatology temperature forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 26 is a plot of the 1971 through 1984 calendar year absolute error minimum temperature scores for the man, KL, and climatology temperature forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 27(a,b,c) is similar to figure 24(a,b,c) except the temperature is maximum.

Figure 28(a,b,c) is similar to figure 25(a,b,c) except the temperature is maximum.

Figure 29 is similar to figure 26 except the temperature is maximum.

Figure 30 is a plot of the 1972 through 1984 calendar year absolute error ( $\text{minimum} + \text{maximum}) \div 2$  temperature scores for the man, KL, and climatology temperature forecasts verifying on days  $(3+4+5) \div 3$  after forecast day.

Figure 31 is a plot of the calendar year 1984 monthly mean 5-class temperature skill scores for the man, forecast persistence (FP - persistence of the 1-5 day mean temperature forecast as a 6-10 day), linear regression (LR - see NMC ON 259 of June 82), and observed (T OBS-persistence of the 5 day mean observed temperatures as a 6-10 day forecast) mean temperature forecasts verifying 6 to 10 day after forecast day. (See Appendix B for an explanation of this score.)

Figure 32 is a plot of the 7 year (1978-1984) average monthly mean 5 class temperature skill scores for the man, FP, LR and T OBS mean temperature forecasts verifying 6 to 10 days after forecast day.

Figure 33 is a plot for the 1978 through 1984 calendar year 5-class temperature skill scores for the man, FP, LR and T OBS mean temperature forecasts verifying 6 to 10 days after forecast day.

Figure 34 is similar to figure 31 except the temperature skill scores are 3-class.

Figure 35 is similar to figure 32 except the temperature skill scores are 3-class.

Figure 36 is similar to figure 33 except the temperature skill scores are 3-class.

Figure 37 depicts the 100 stations in the United States where the precipitation forecasts are verified.

Figure 38 is an example of a day 3, 4, or 5 precipitation forecast. The dashed lines are the 24-hour departure from normal probability of precipitation (DN POP) forecast for January 3. The solid lines are the 24-hour climatological (normal) probability of precipitation (NPOP) for the first 15 days of January. A total of  $(DN\ POP + NPOP) \geq 30$  is considered "yes" forecast of precipitation ( $\geq .01$  inch). All stations with an  $(NPOP) \geq 30$  are considered as a "yes" climatological forecast of precipitation.

Figure 39 is a plot off the calendar year 1984 monthly mean Gilman precipitation skill scores for the man, climatology, and NMC/NWP model precipitation forecasts verifying on days 3, 4, and 5 after forecast day. (See Appendix C for an explanation of this score.)

Figure 40 is a plot of the 15 year (1970-1984) average monthly mean Gilman precipitation skill scores for the man and climatology precipitation forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 41 is a plot of the 1970 through 1984 calendar year Gilman precipitation skill scores for the man and climatology precipitation forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 42 is a plot of the 1970 through 1984 Gilman precipitation skill scores for the man and climatology precipitation forecasts verifying on days  $(3+4+5) \div 3$  after forecast day.

Figure 43 is similar to figure 39 except the skill score is Hughes. (See Appendix D for an explanation of this score.)

Figure 44 is similar to figure 40 except the average is for 8 years, the skill score is Hughes, and climatology is not depicted.

Figure 45 is similar to figure 41 and figure 42 except the calendar years are 1977 through 1984 and the skill score is Hughes.

Figure 46 is similar to figure 39 except the skill score is Hughes Probability. (See Appendix E for an explanation of this score.)

Figure 47 is similar to figure 40 except the average is for 7 years and the skill score is Hughes Probability.

Figure 48 is similar to figure 41 and figure 42 except the calendar years are 1978 through 1984 and the skill score is Hughes Probability.

Figure 49 is a plot of the calendar year 1984 monthly mean 3-class precipitation skill scores for the man, NWP/NMC model and climatology mean precipitation forecasts verifying 1 to 5 days after forecast day. (See Appendix F for an explanation of this score.)

Figure 50 is a plot of the 7 year (1978-1984) average monthly mean 3-class precipitation skill scores for the man and climatology mean precipitation forecasts verifying 1 to 5 days after forecast day.

Figure 51 is a plot of the 1978 through 1984 calendar year 3-class precipitation skill scores for the man, NMC/NWP model and climatology mean precipitation forecasts verifying 1 to 5 days after forecast day.

Figure 52 is similar to figure 49 except the observed (P OBS - persistence of the 5-day mean observed precipitation as a 6-10 day forecast) is depicted and the forecast is for 6 to 10 days.

Figure 53 is similar to figure 50 except the forecast is for 6 to 10 days.

Figure 54 is similar to figure 51 except the forecast is for 6 to 10 days.

Figures 55 through 66 and 67 through 78 are plots of the calendar year 1984 monthly mean unstandardized/standardized correlation scores for the man, LFM, ECMWF, LR, NMC/NWP model and climatology North American area mean sea-level pressure progs verifying on days 1 through 9 after forecast day.

Figures 79 through 90 are plots of the calendar year 1984 monthly mean standardized correlation scores for the LFM, LR, ECMWF, and NMC/NWP model North American area 500-mb progs verifying on days 1 through 9 after forecast day.

Figures 91 through 102 are plots of the calendar year 1984 absolute error minimum and maximum temperature scores for the man, KL, LR and climatology temperature forecasts verifying on days 1 through 7 after forecast day.

**SECTION 1****Man & Machine (NMC/NWP Guidance)****Mean Sea Level Pressure and 500 MB Correlation Scores**

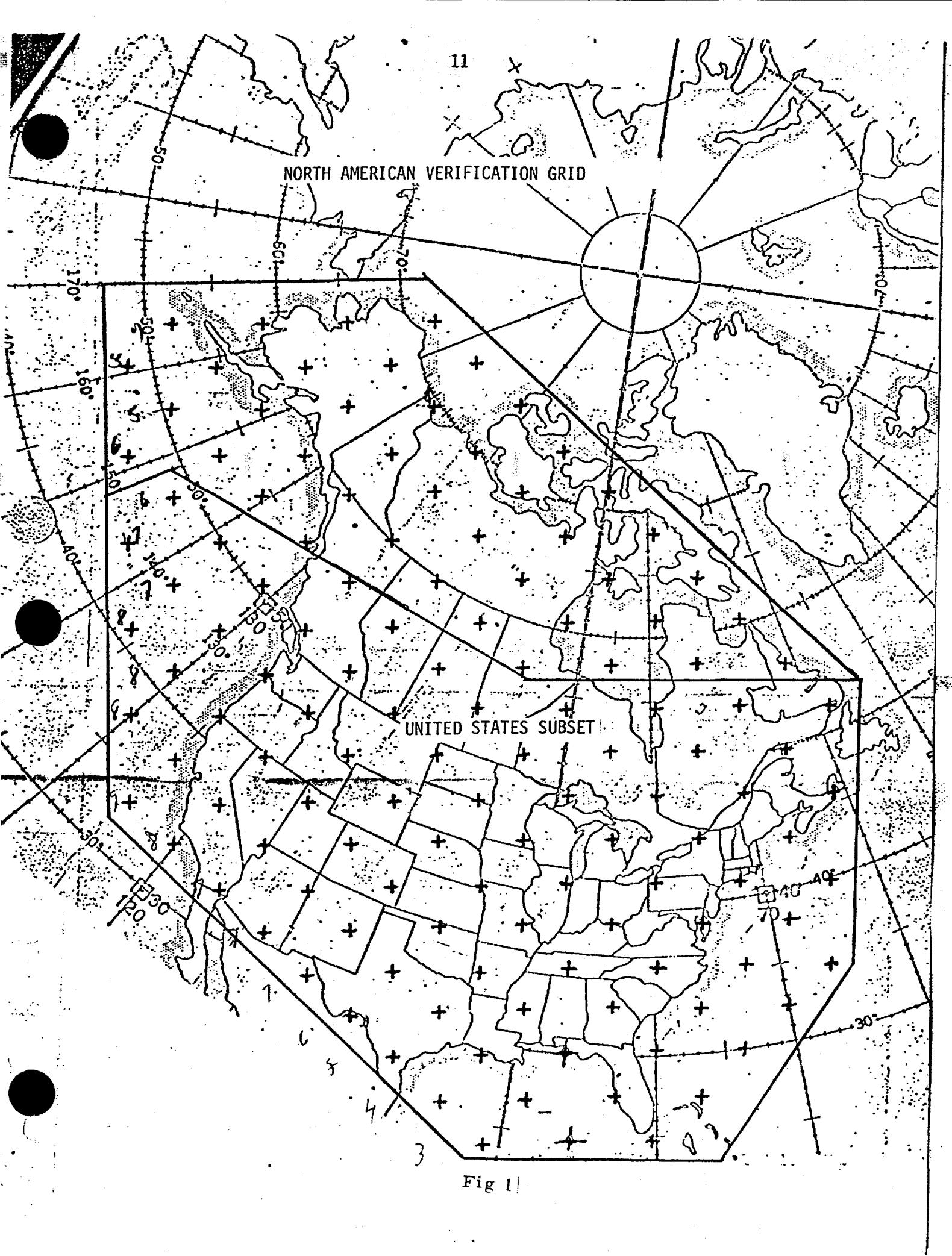


Fig 1

DAYS 3, 4, AND 5 NORTH AMERICAN AREA MSLP  
STANDARDIZED CORRELATION SCORES FOR 1984

CORRELATION (E X 100)

100

95

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

5

00

NMC/NWP MODEL  
MAN

CLIMATOLOGY = 0

O=RECORD SCORE

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 2

day 3 man

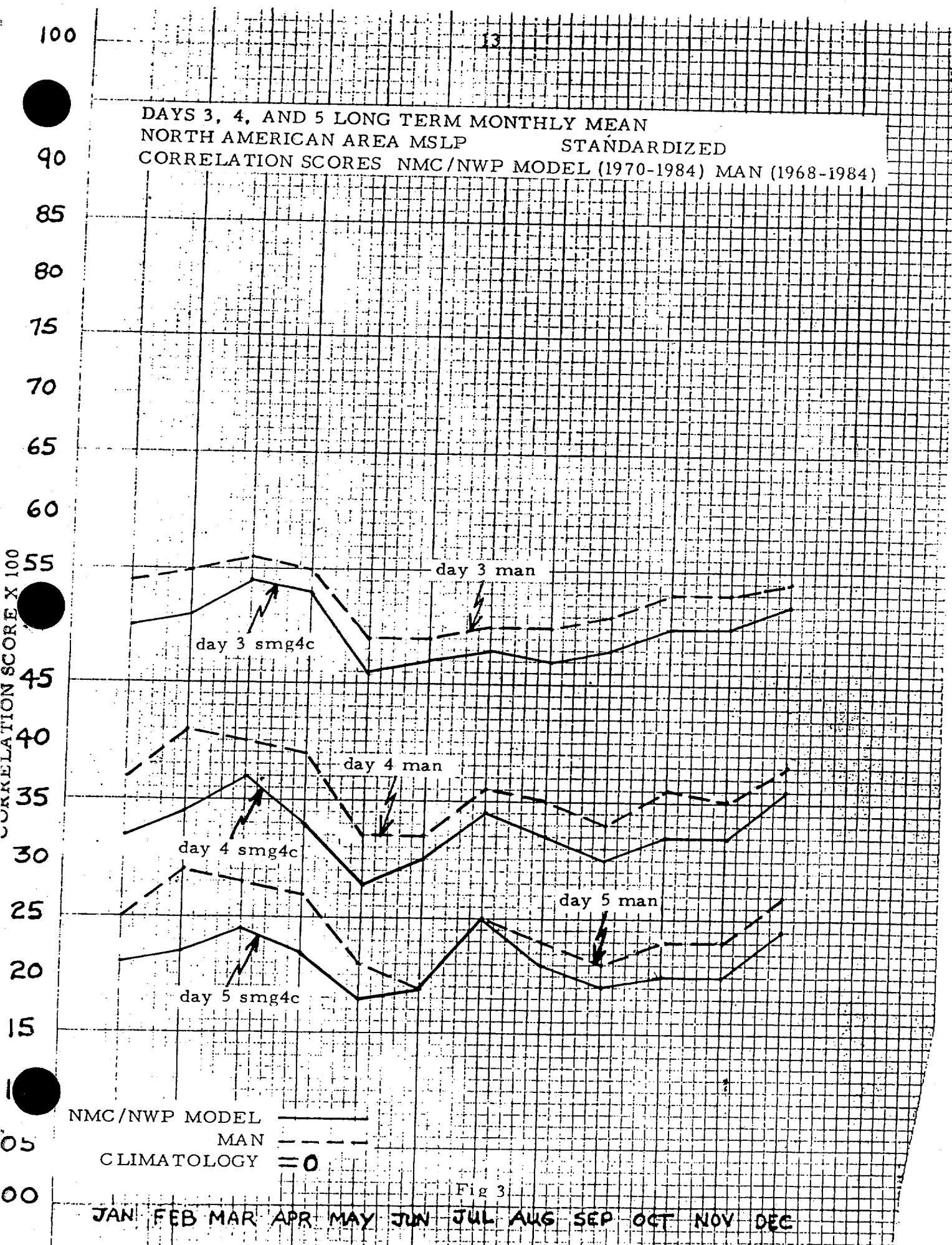
day 3 smg4c

day 4 man

day 5 smg4c

day 5 man

day 4 smg4c



14

DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE  
NORTH AMERICAN AREA MSLP STANDARDIZED  
CORRELATION SCORES FOR 1968-1984

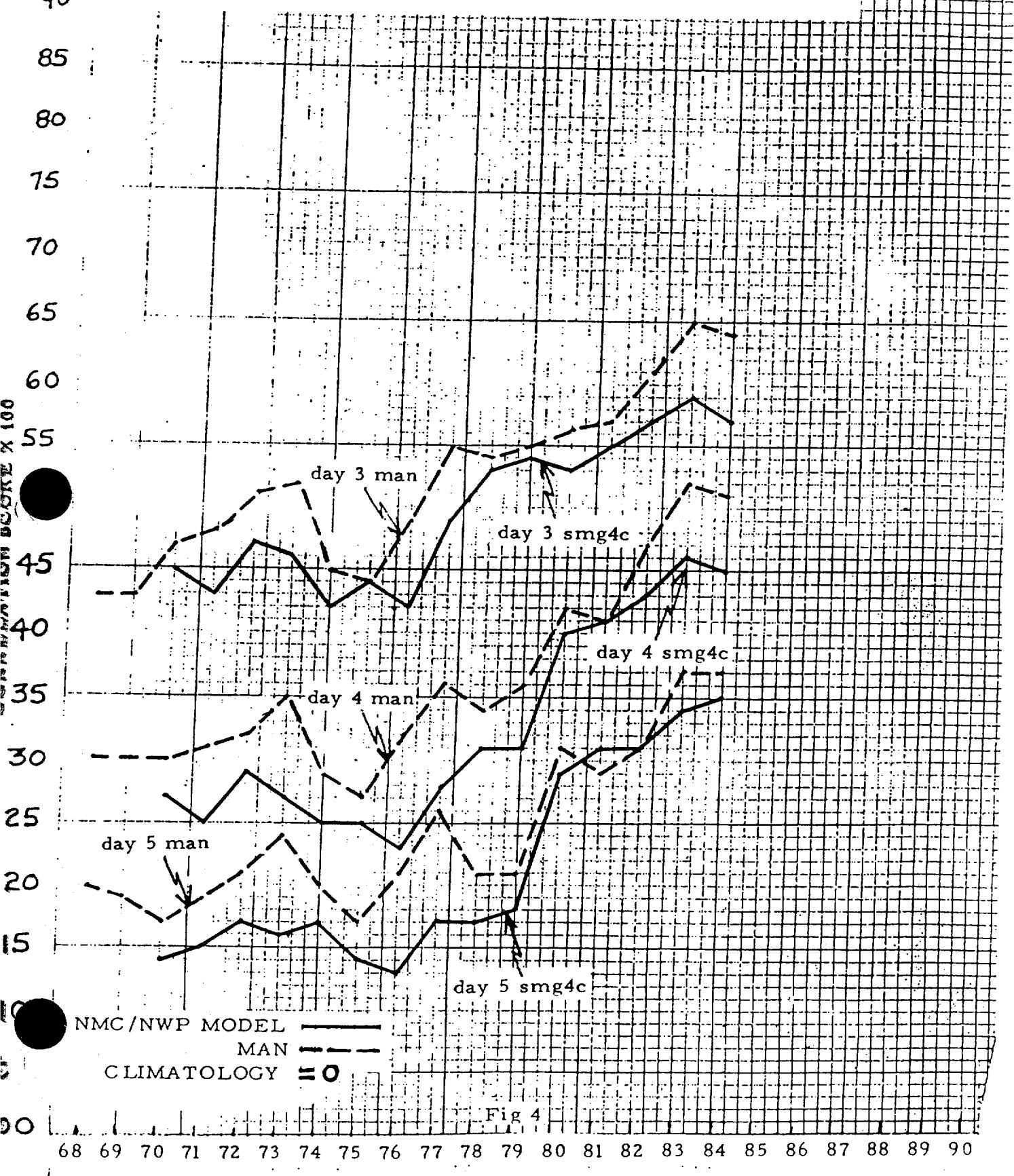
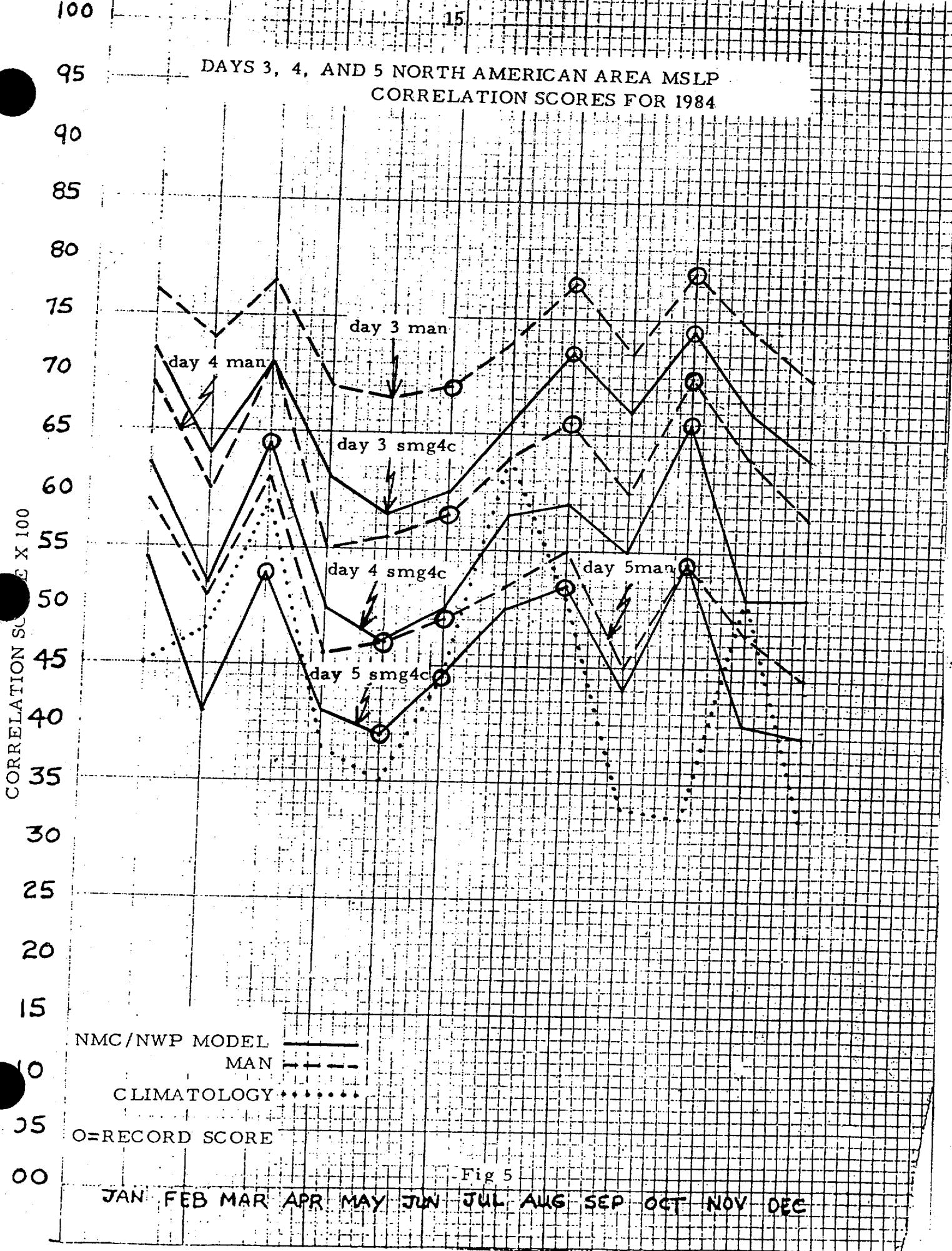
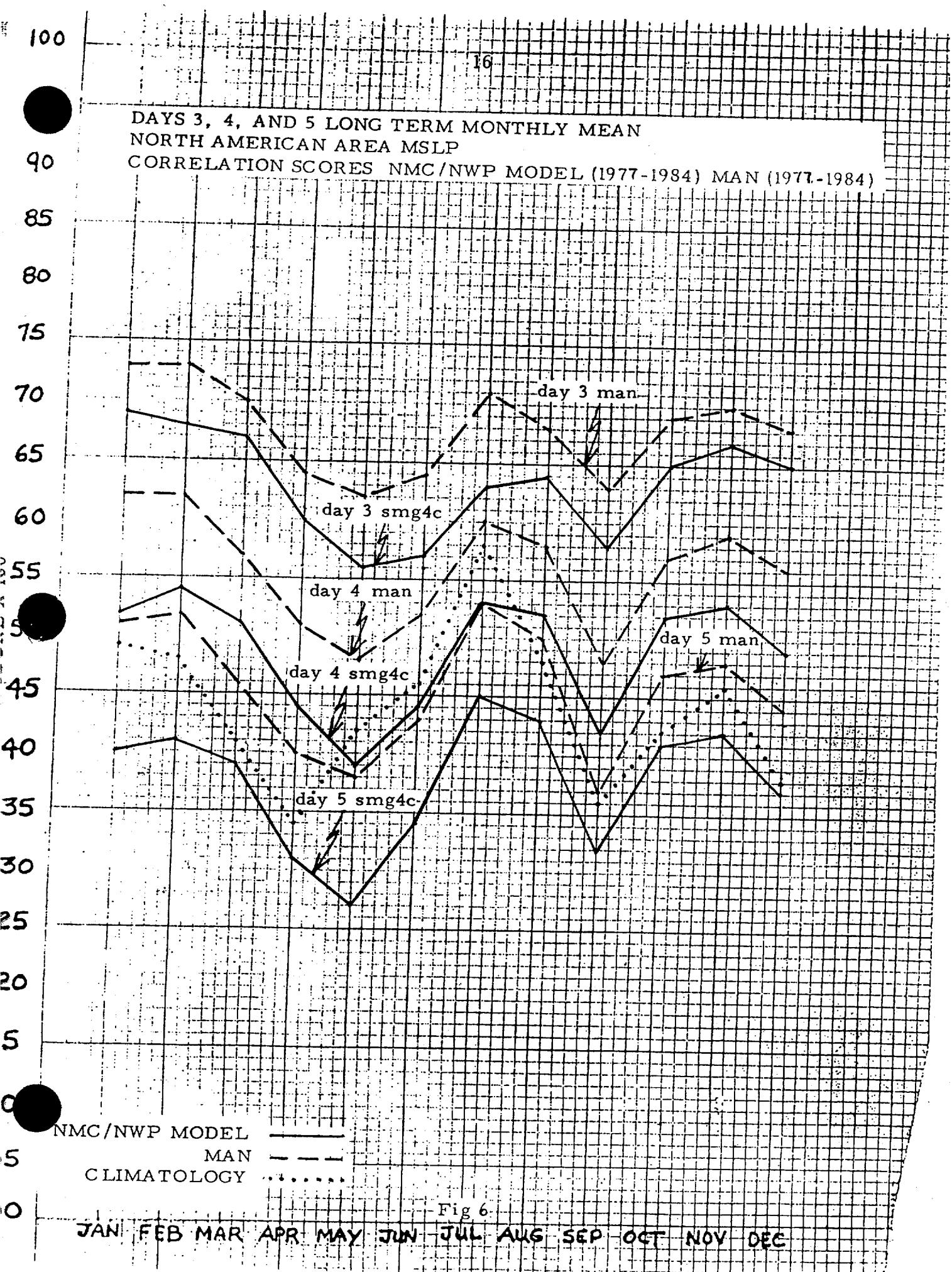


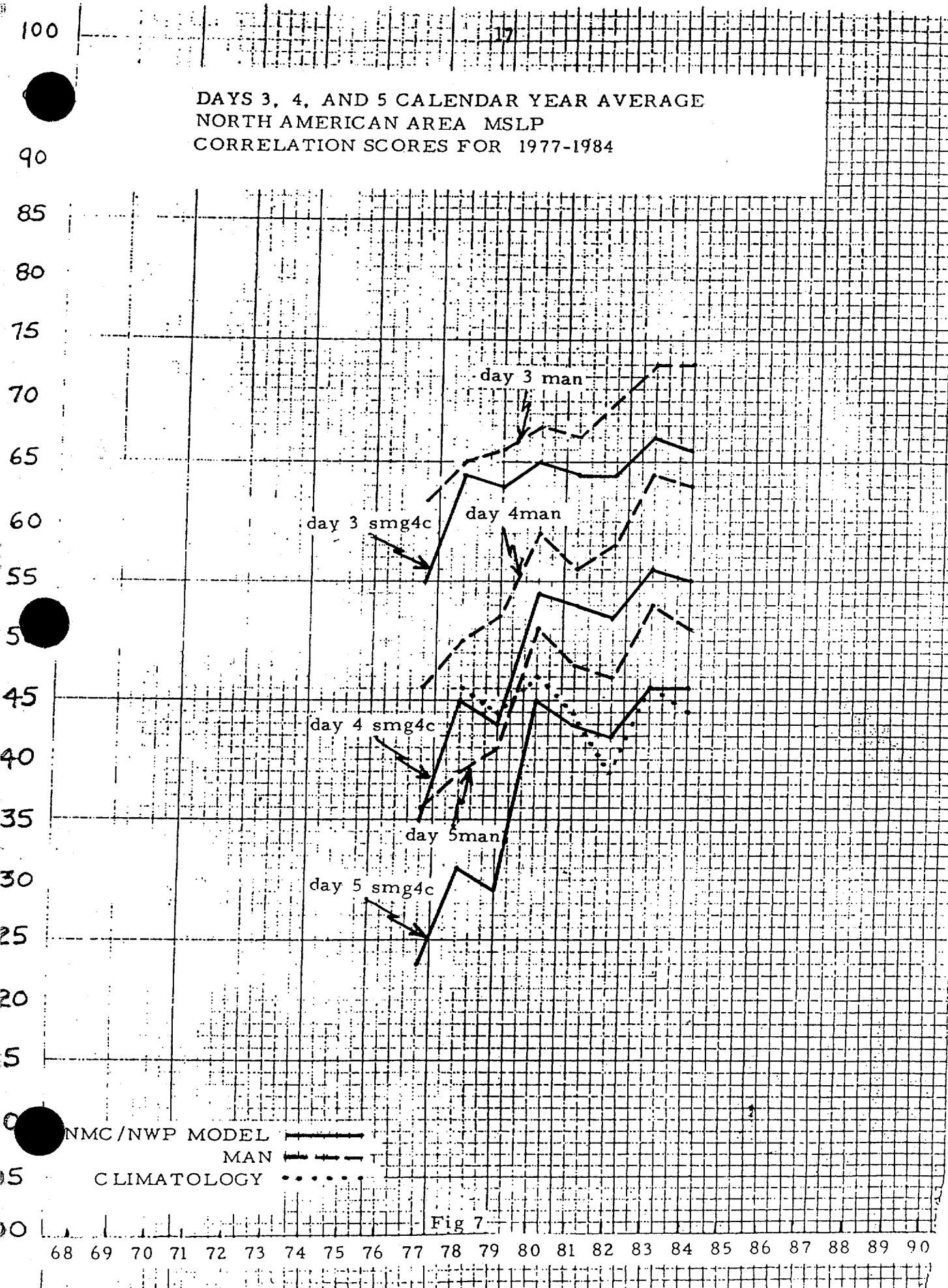
Fig 4

DAYS 3, 4, AND 5 NORTH AMERICAN AREA MSLP  
CORRELATION SCORES FOR 1984





DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE  
NORTH AMERICAN AREA MSLP  
CORRELATION SCORES FOR 1977-1984



100

95

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

5

00

16  
 DAYS 3, 4, AND 5 NORTH AMERICAN AREA  
 STANDARDIZED CORRELATION SCORES FOR 1984

500 MB

CORRELATION SCORE X 100

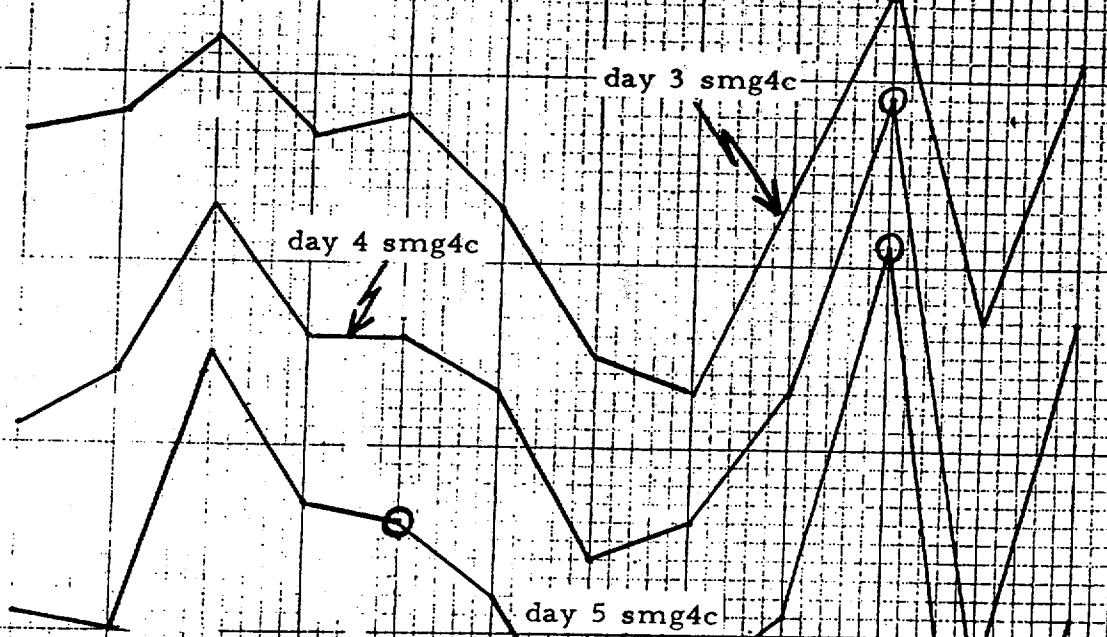
NMC/NWP MODEL

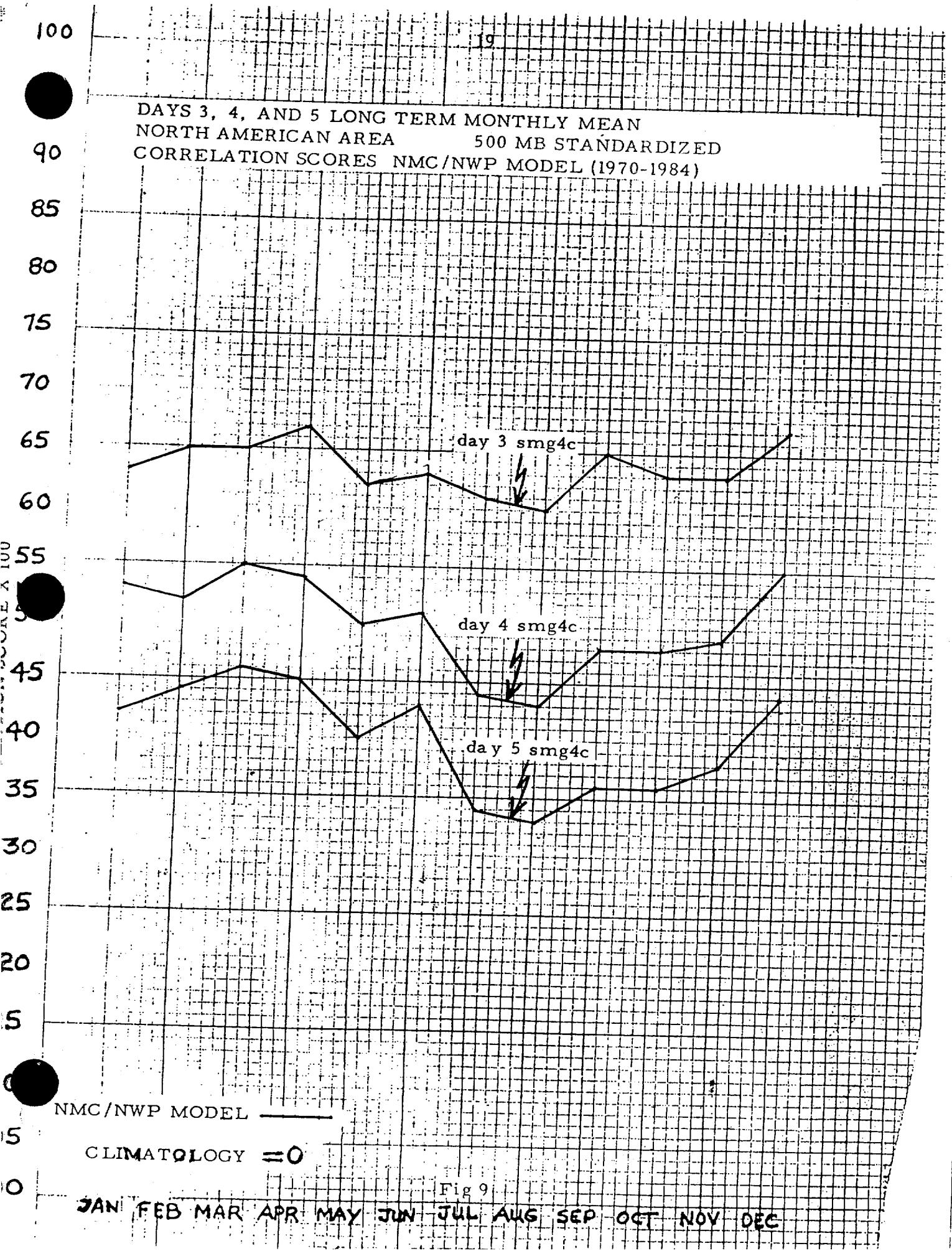
CLIMATOLOGY = 0

O=RECORD SCORE

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 8



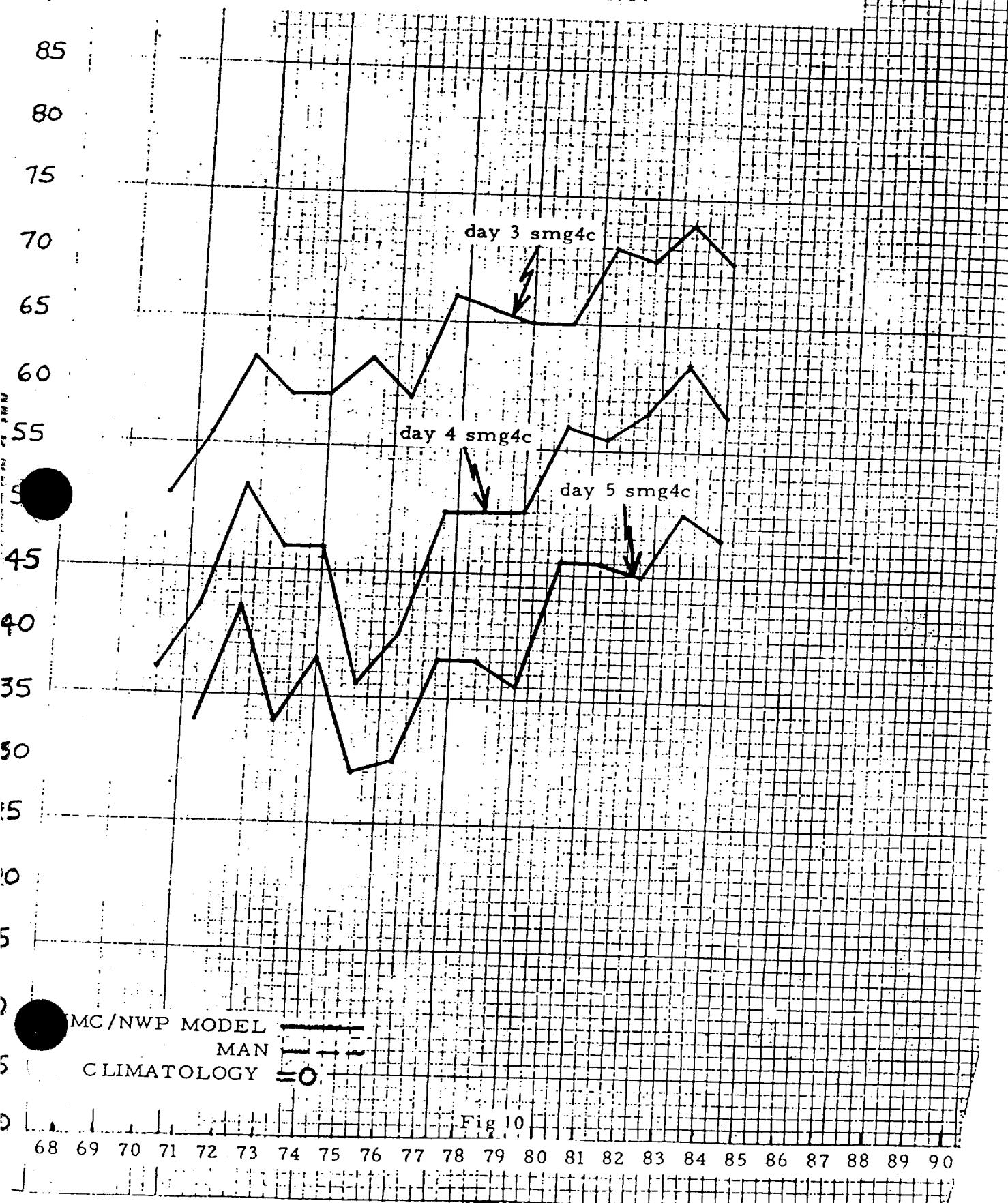


100

20

90

DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE  
 NORTH AMERICAN AREA      500MB STANDARDIZED  
 CORRELATION SCORES FOR 1970-1984



100

21

95

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

05

00

DAYS 3, 4, AND 5 UNITED STATES AREA MSLP  
STANDARDIZED CORRELATION SCORES FOR 1984

CORRELATION SCORE X 100

NMC/NWP MODEL

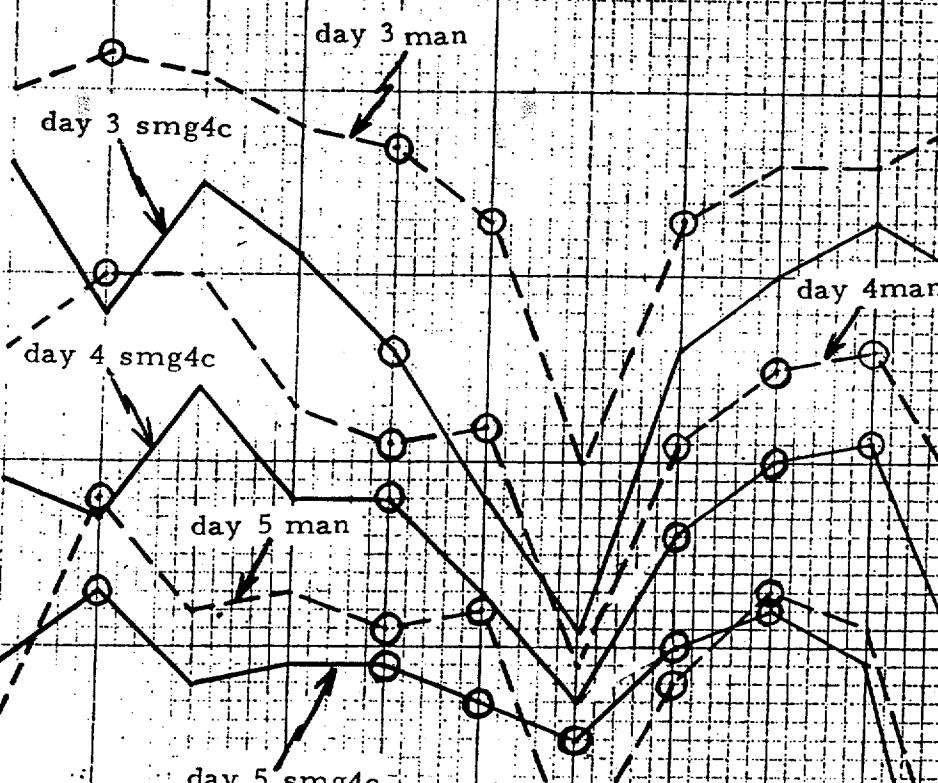
MAN

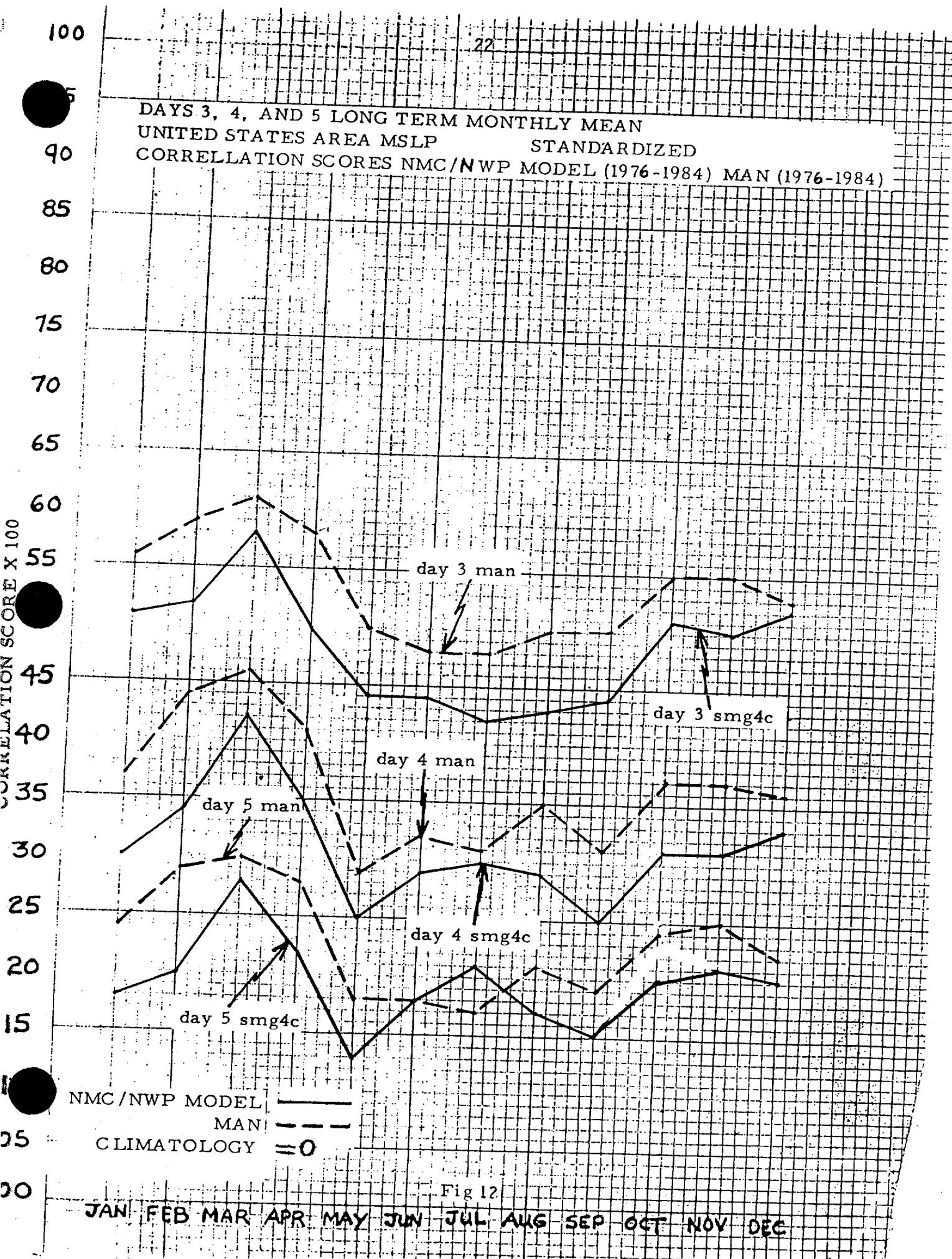
CLIMATOLOGY

O=RECORD SCORE

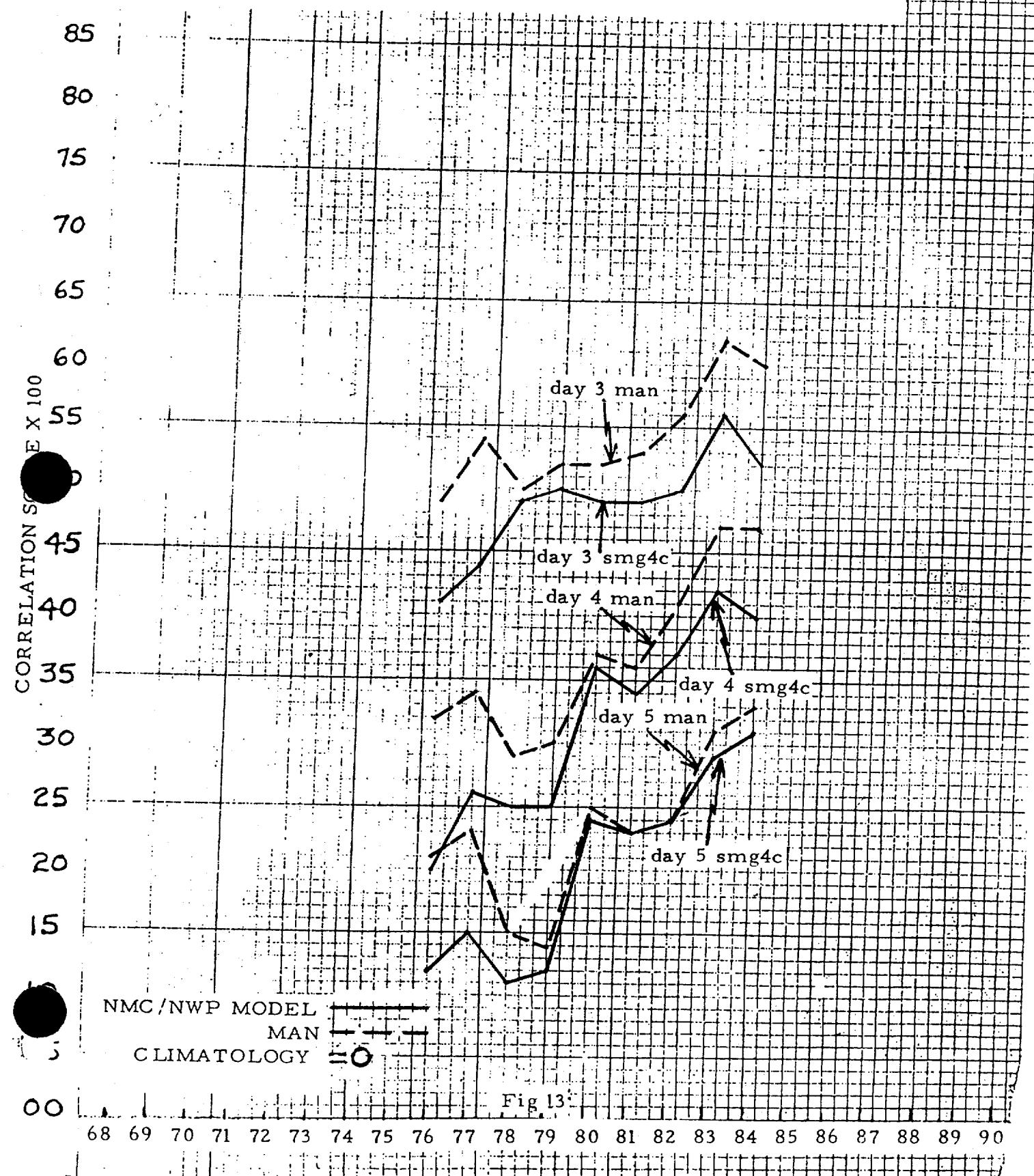
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 11

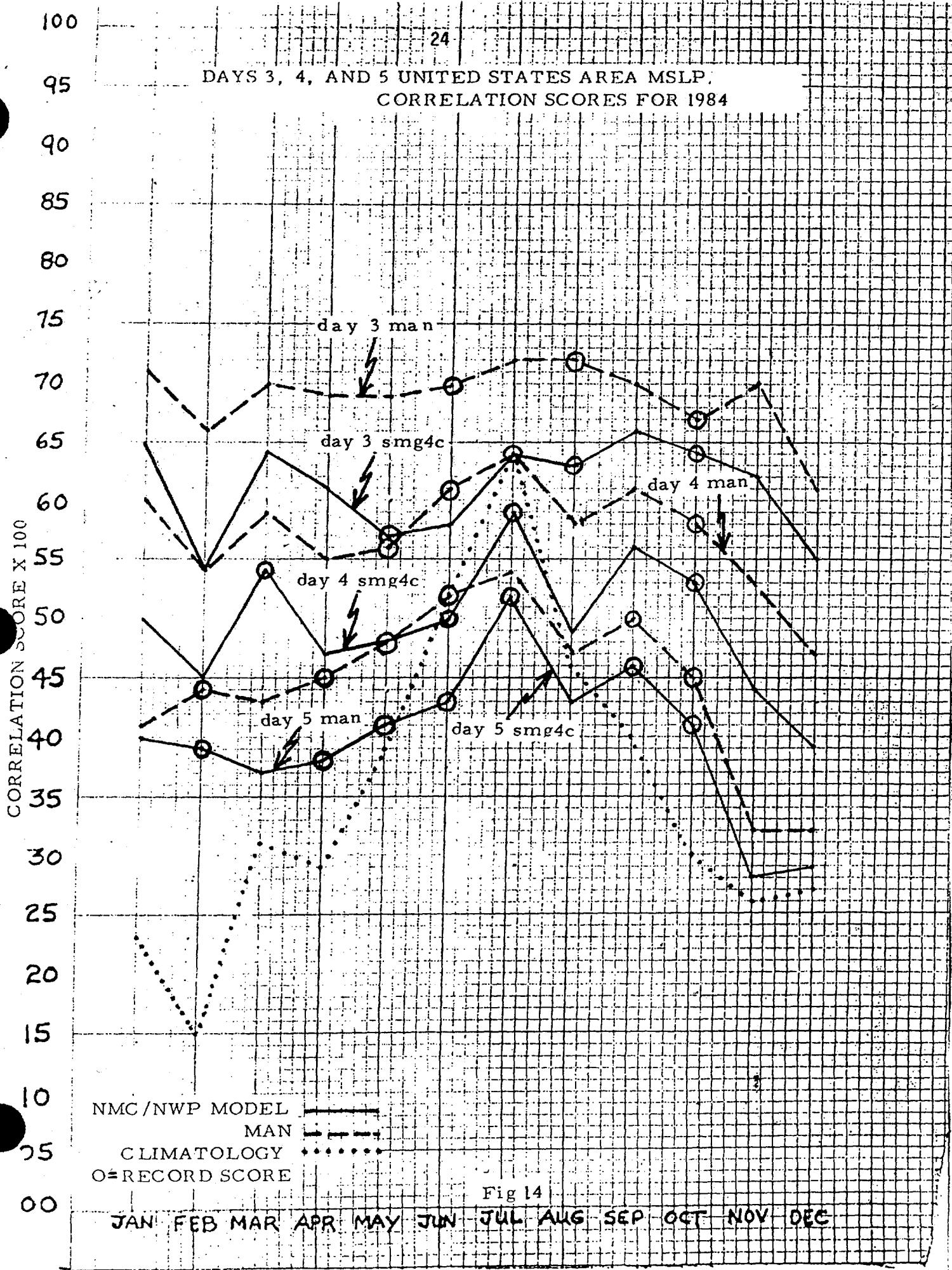


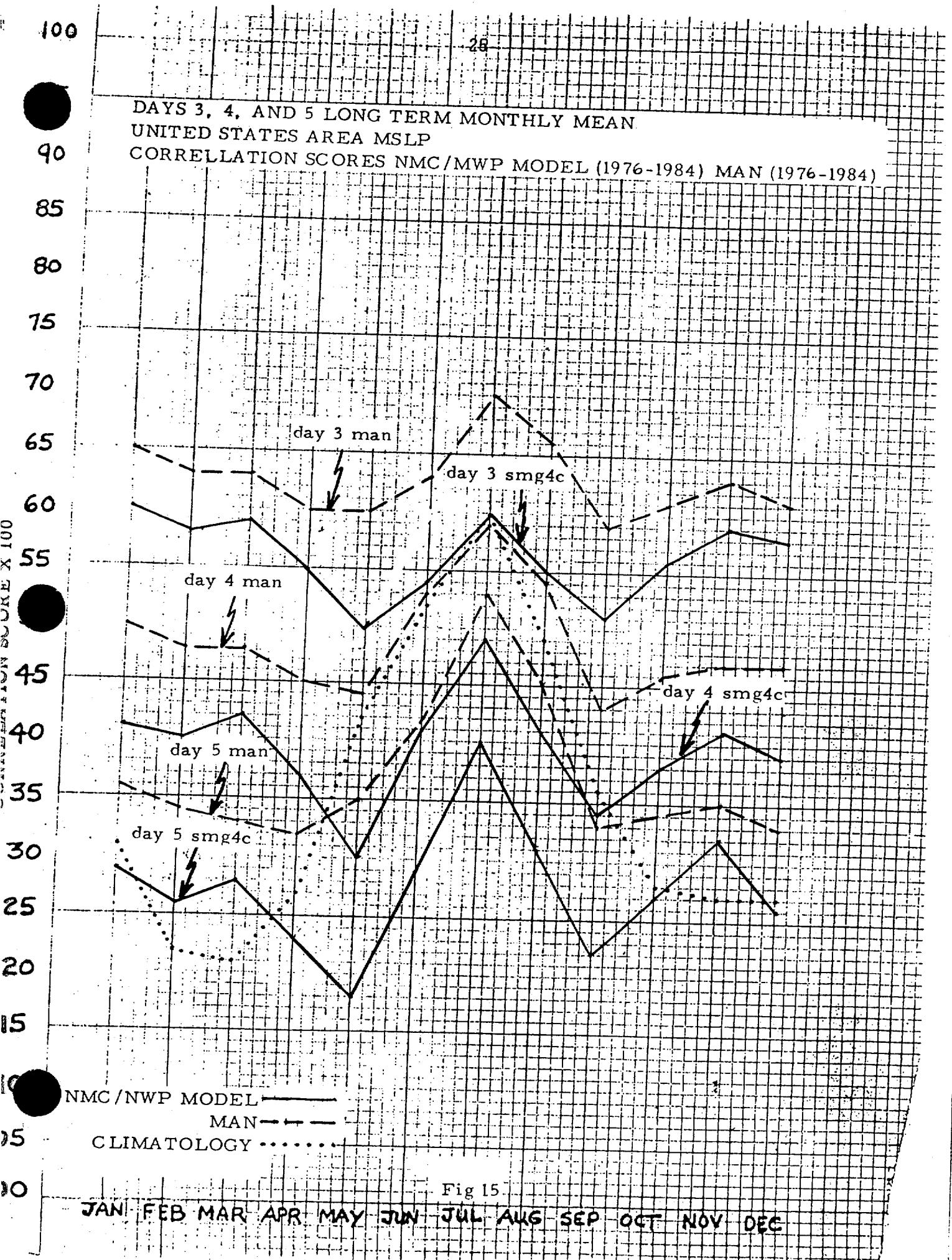


DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE  
 UNITED STATES AREA MS LP STANDARDIZED  
 CORRELATION SCORES FOR 1976-1984



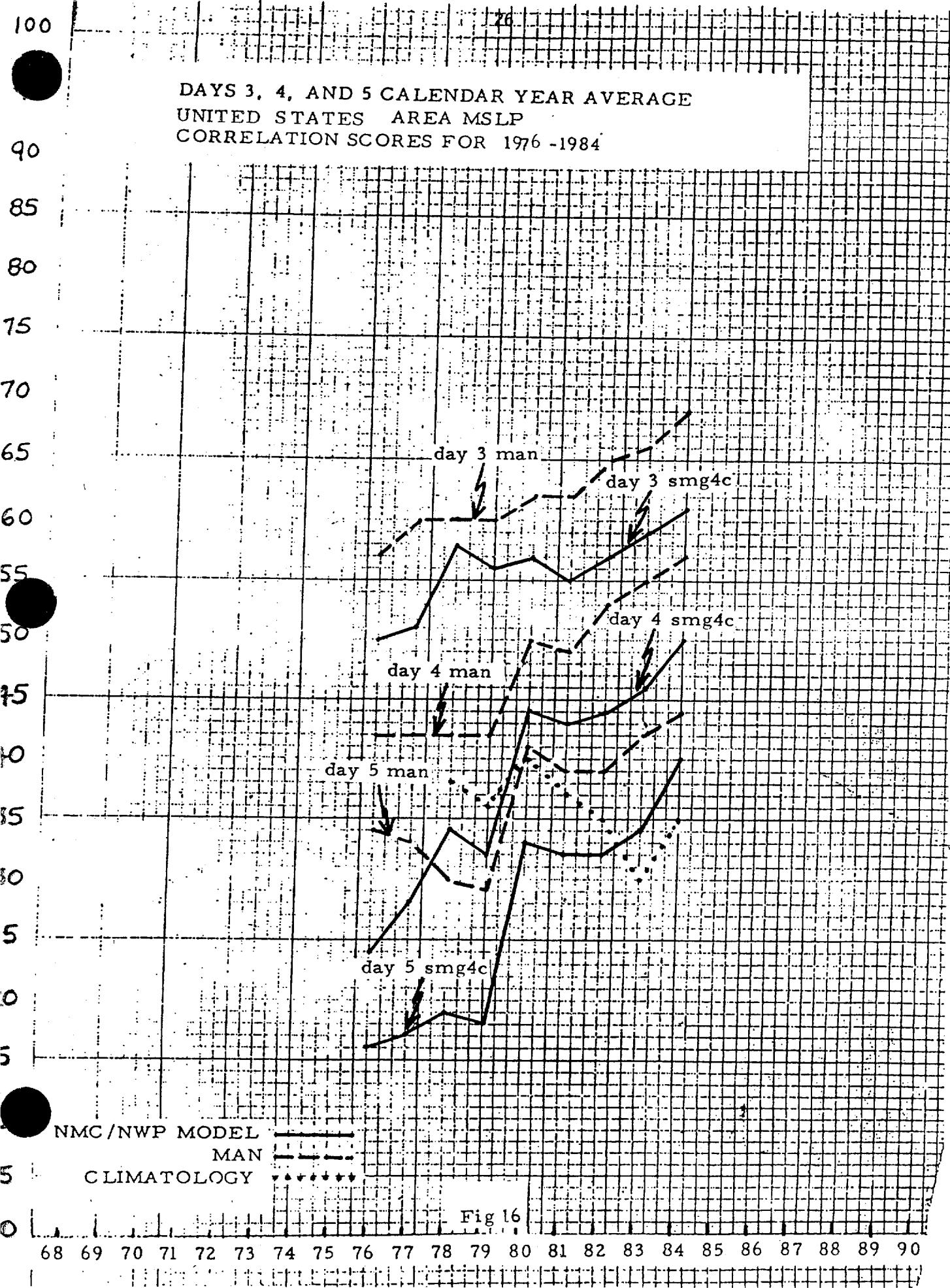
DAYS 3, 4, AND 5 UNITED STATES AREA MSLP  
CORRELATION SCORES FOR 1984

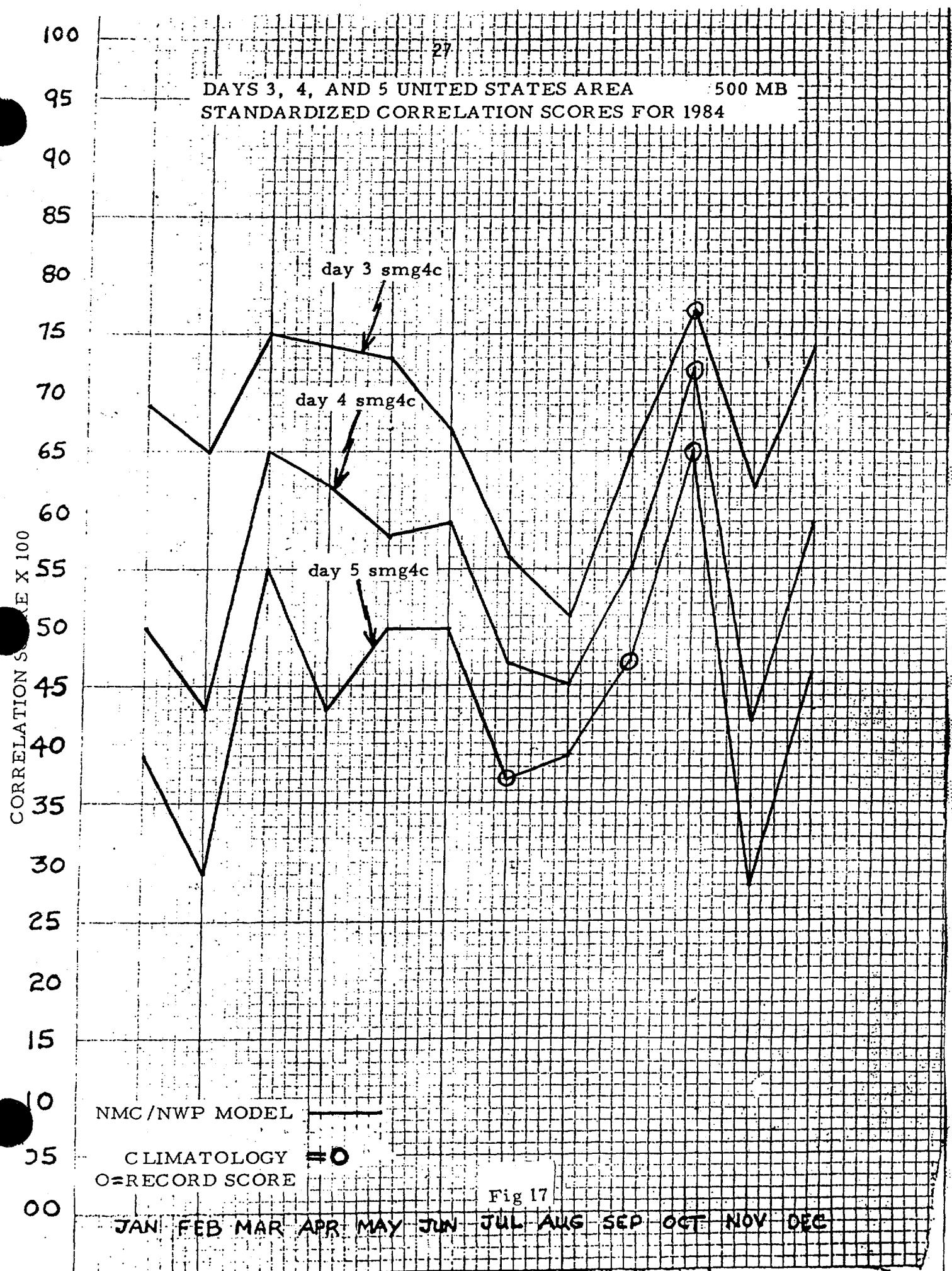


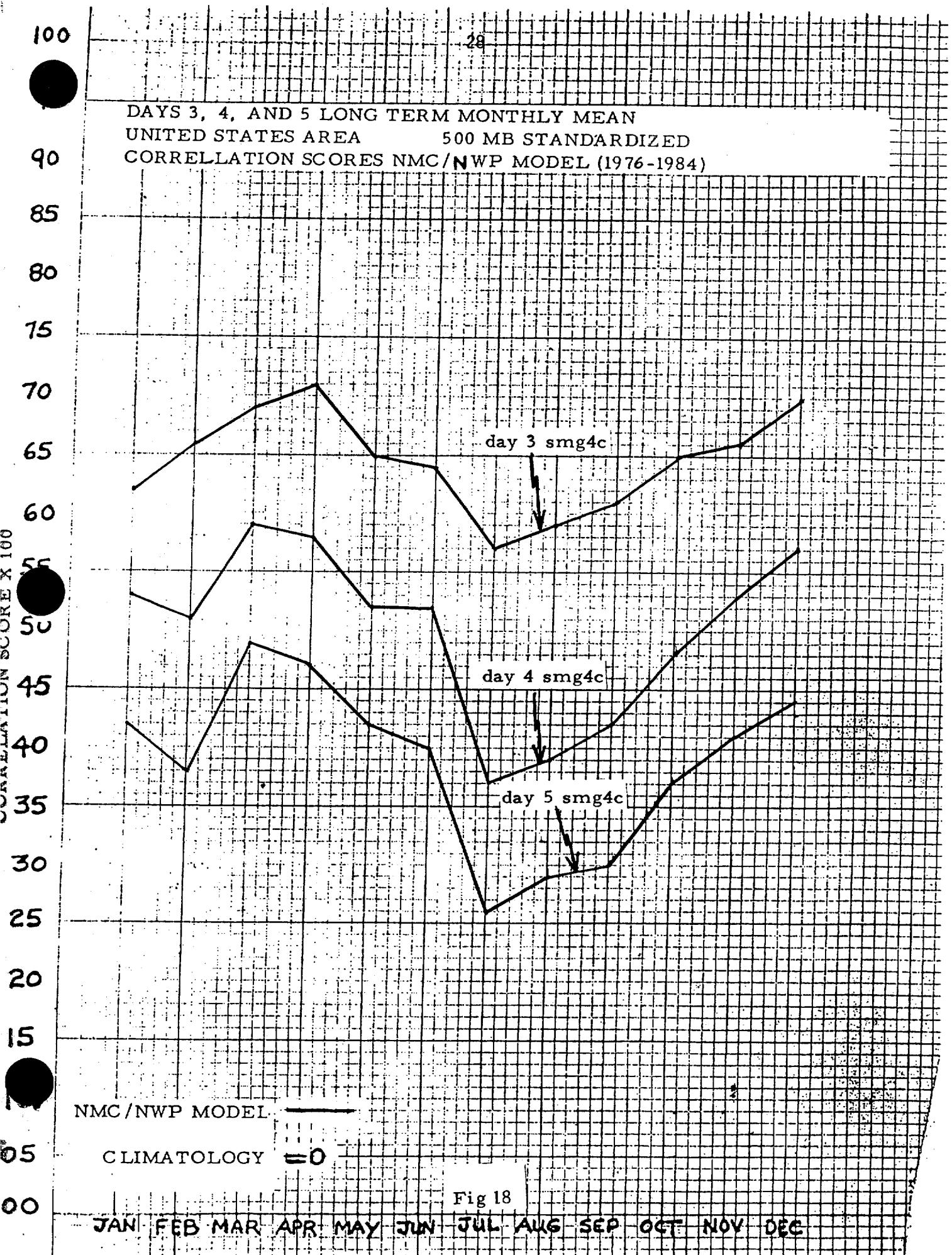


76

DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE  
UNITED STATES AREA MSLP  
CORRELATION SCORES FOR 1976 -1984







100

5

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

NMC/NWP MODEL

CLIMATOLOGY = 

29

DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE  
 UNITED STATES AREA      500MB STANDARDIZED  
 CORRELATION SCORES FOR 1978-1984

CORRELATION SCORE X 100

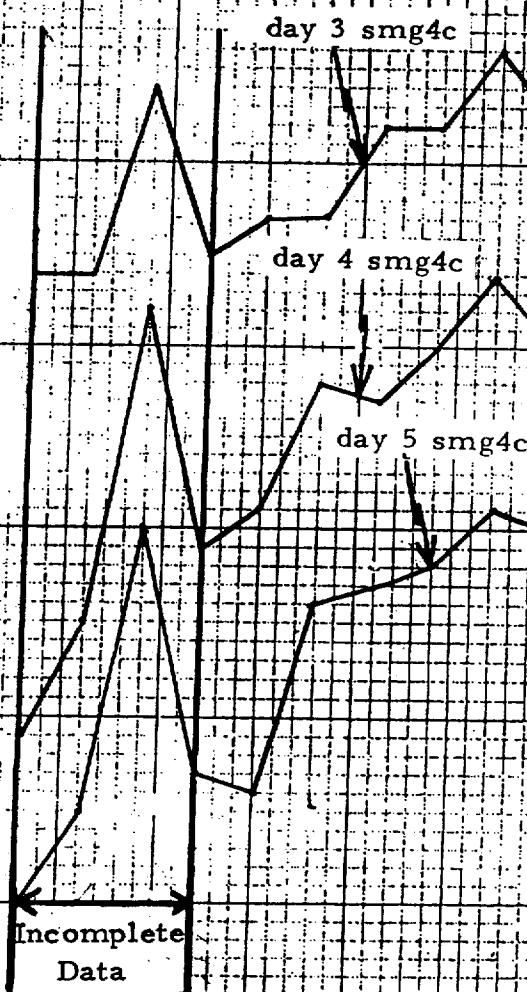
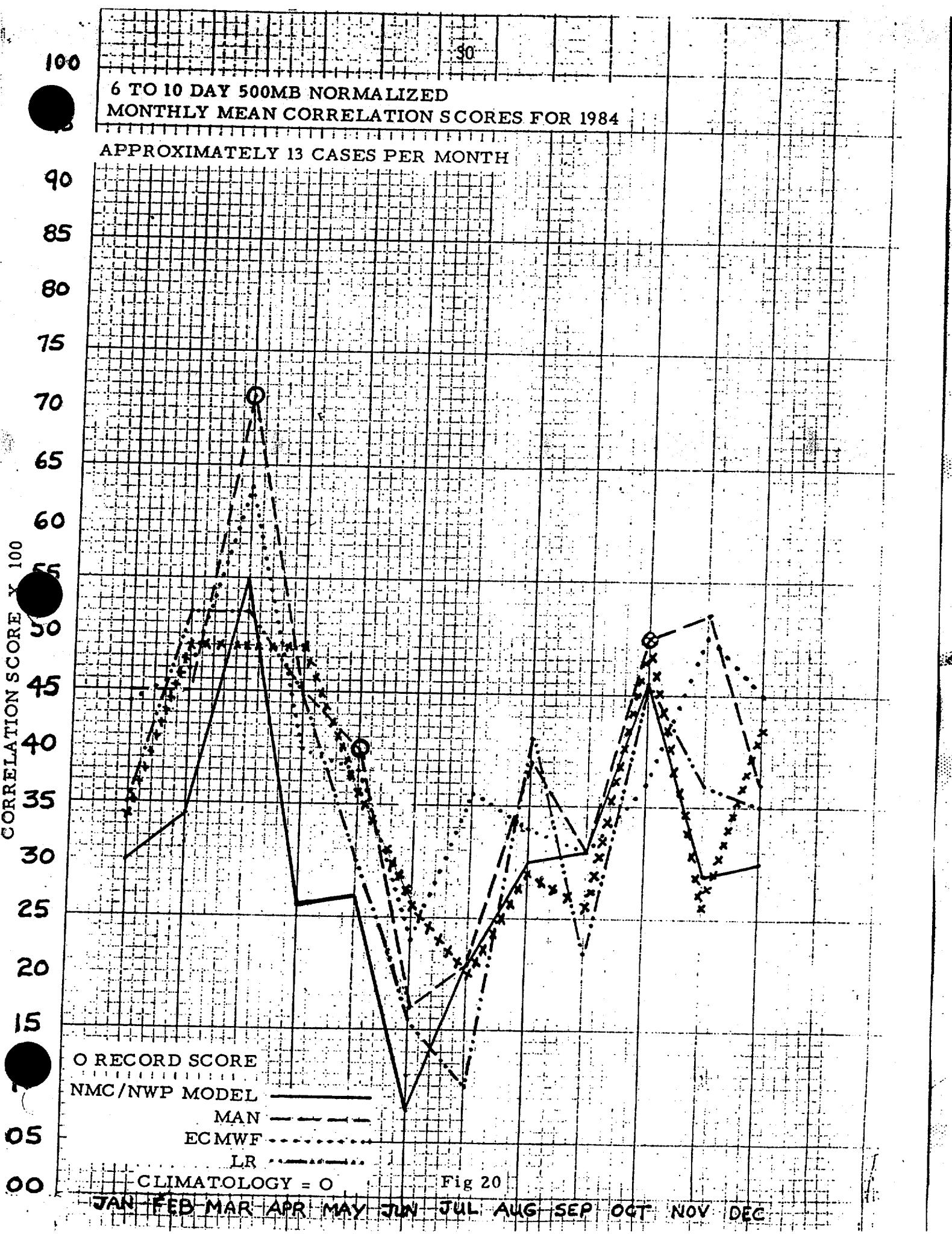


Fig 19



6 TO 10 DAY 500MB NORMALIZED LONG TERM  
MONTHLY MEAN CORRELATION SCORES FOR (1979-1984)

APPROXIMATELY 13 CASES PER MONTH

CORRELATION SCORE X 100

100

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

5

0

NMC/NWP MODEL

MAN

LR

CLIMATOLOGY = 0

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 21.

100

95

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

5

CORRELATION SCORE X 100

6 TO 10 DAY 500MB CALENDAR YEAR AVERAGE NORMALIZED  
MONTHLY MEAN CORRELATION SCORES FOR 1979 - 1984

APPROXIMATELY 13 CASES PER MONTH

NMC/NWP MODEL

MAN

ECMWF

LR

CLIMATOLOGY = 0

32

Fig 22

76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97

**SECTION 2**  
**Man & Machine (KL Guidance)**  
**Absolute Error Temperature Scores**

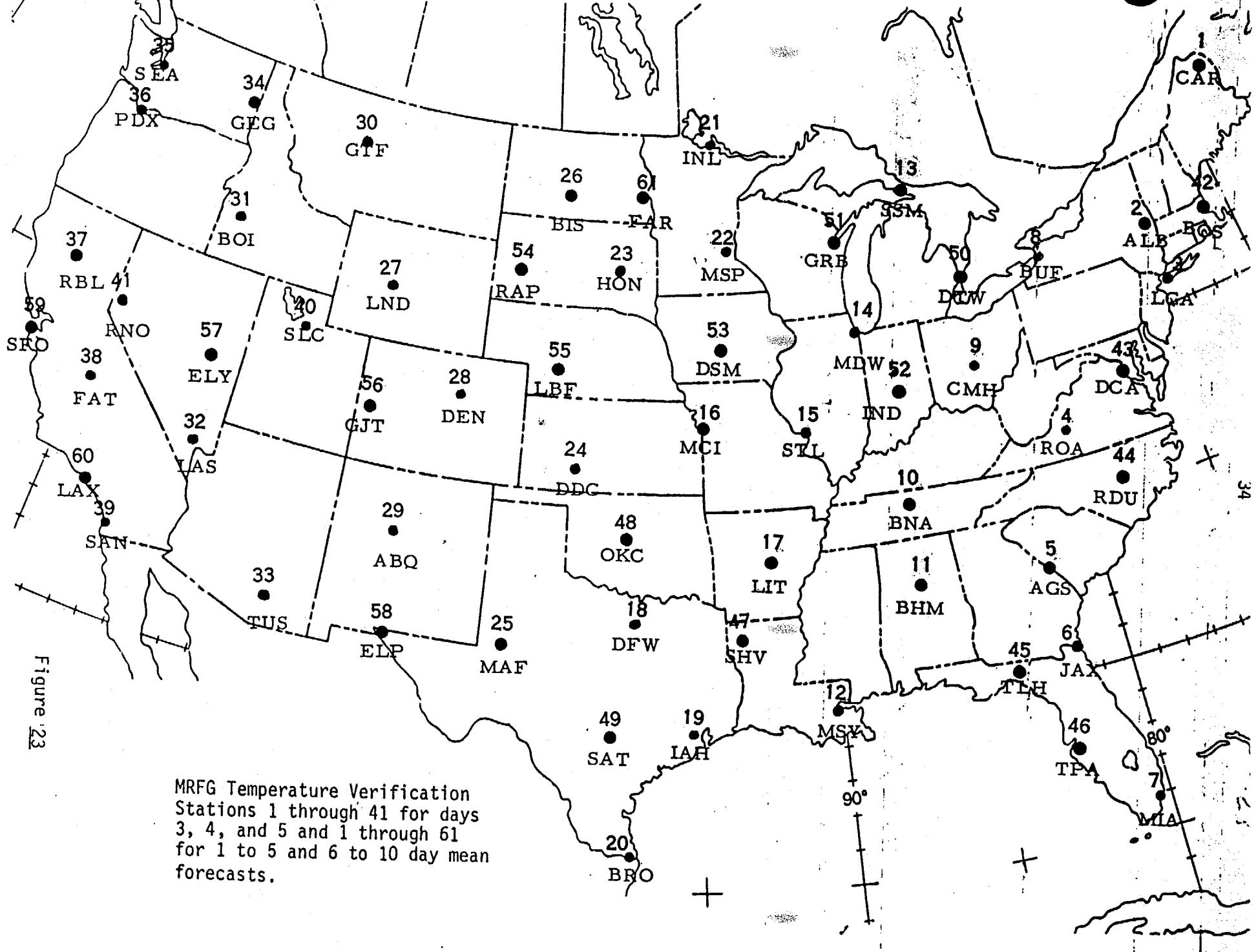


Figure 23

DAY 13 BI-MONTHLY MEAN MINIMUM TEMPERATURE

ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1984

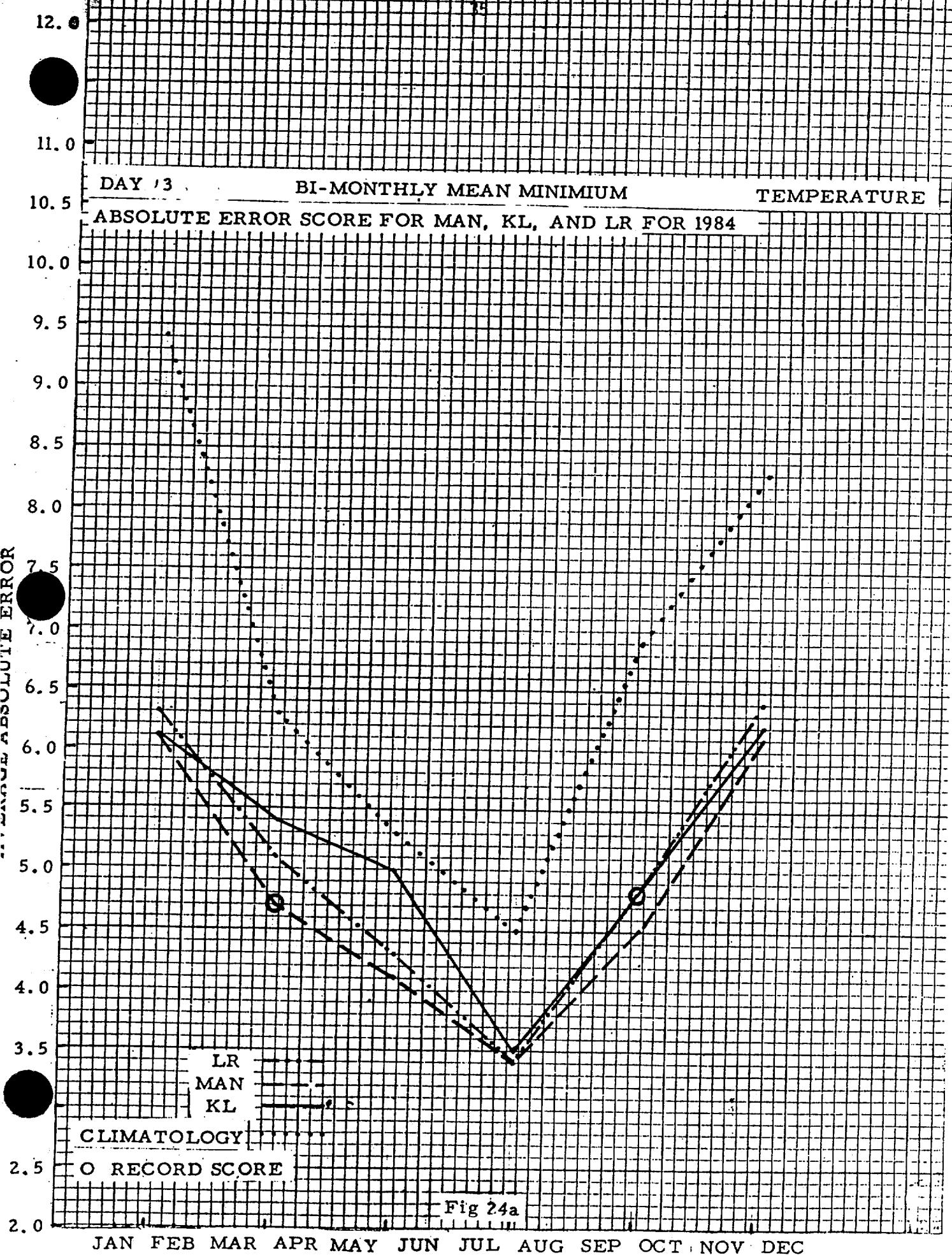
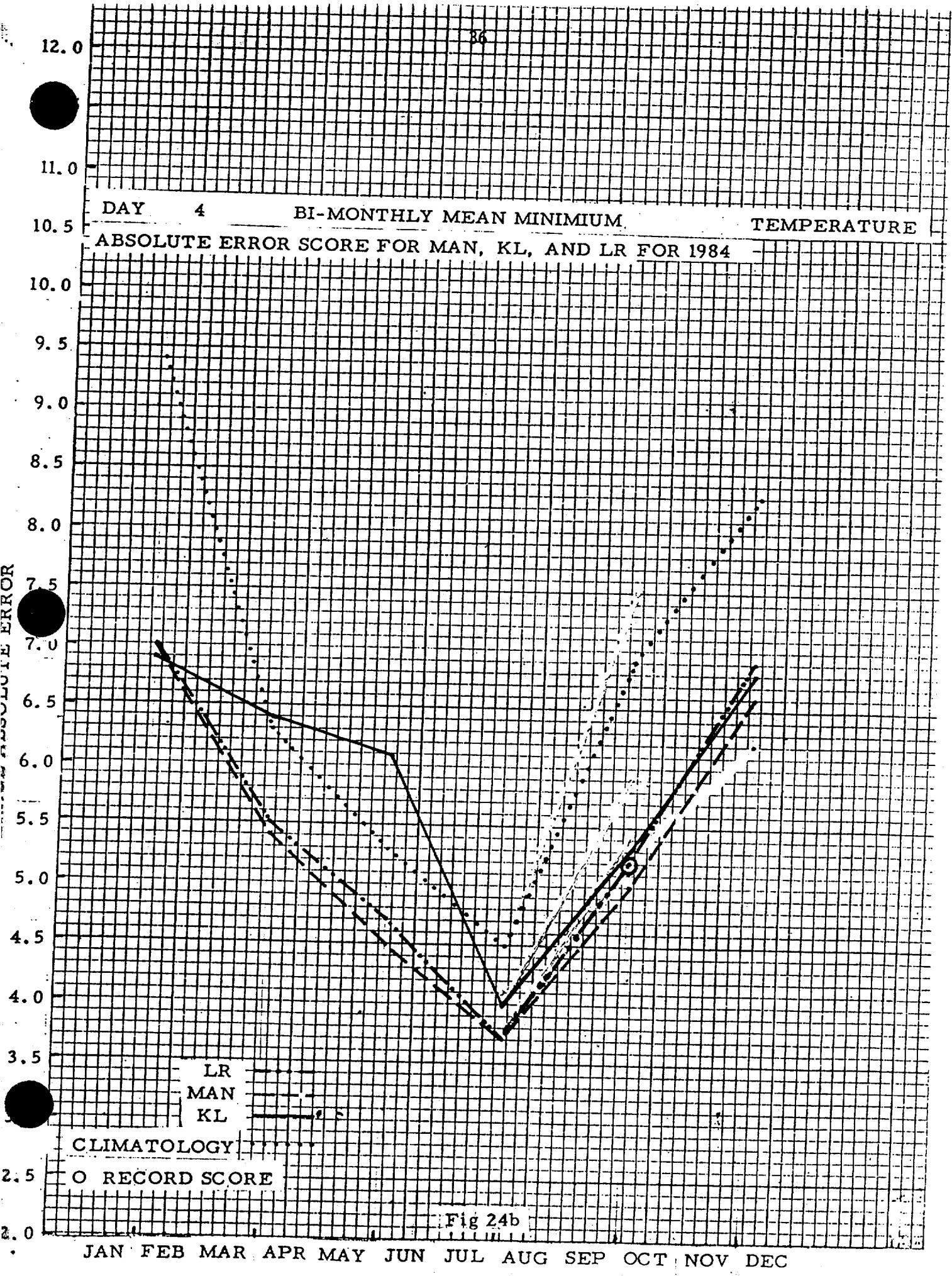
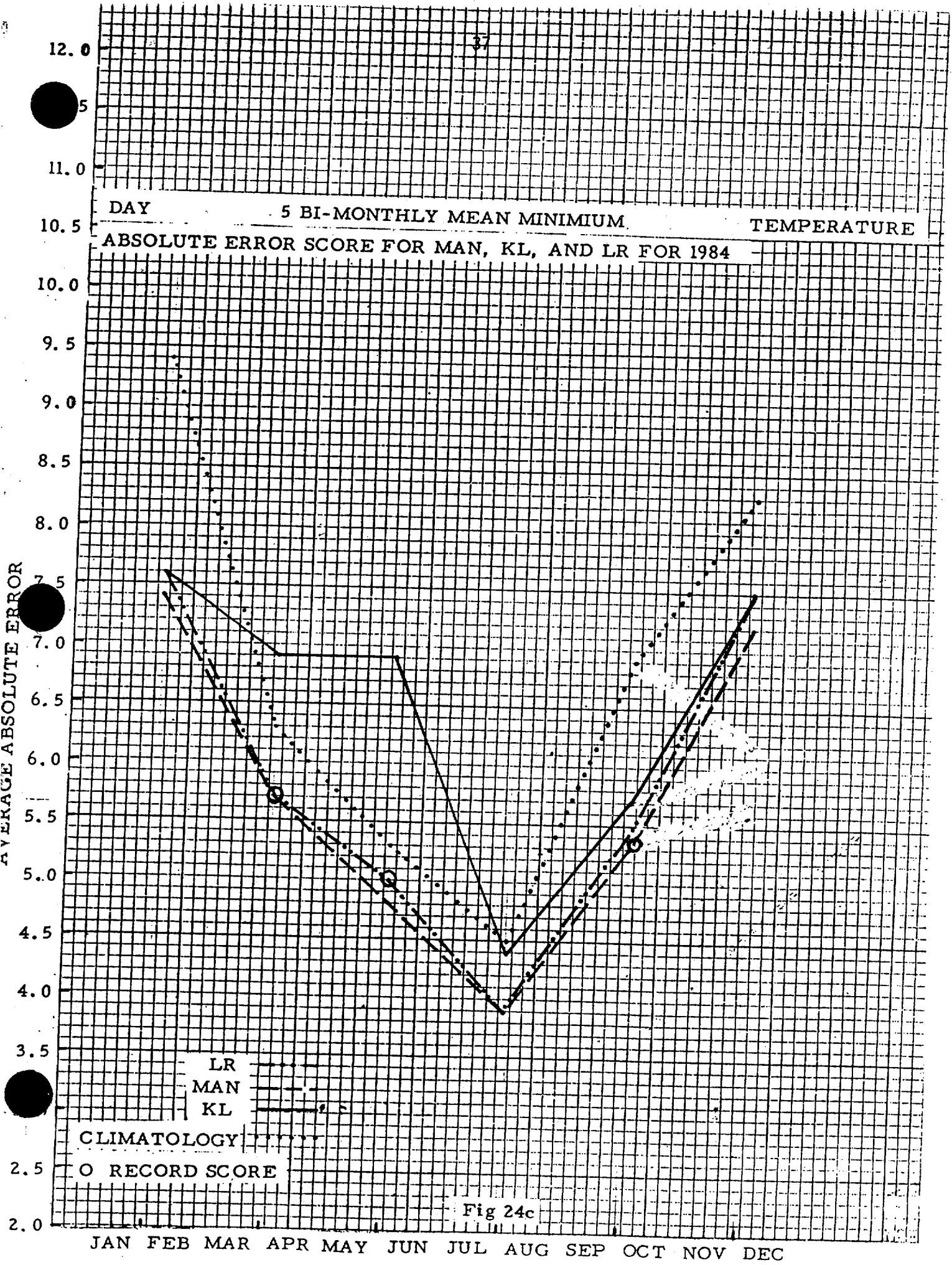
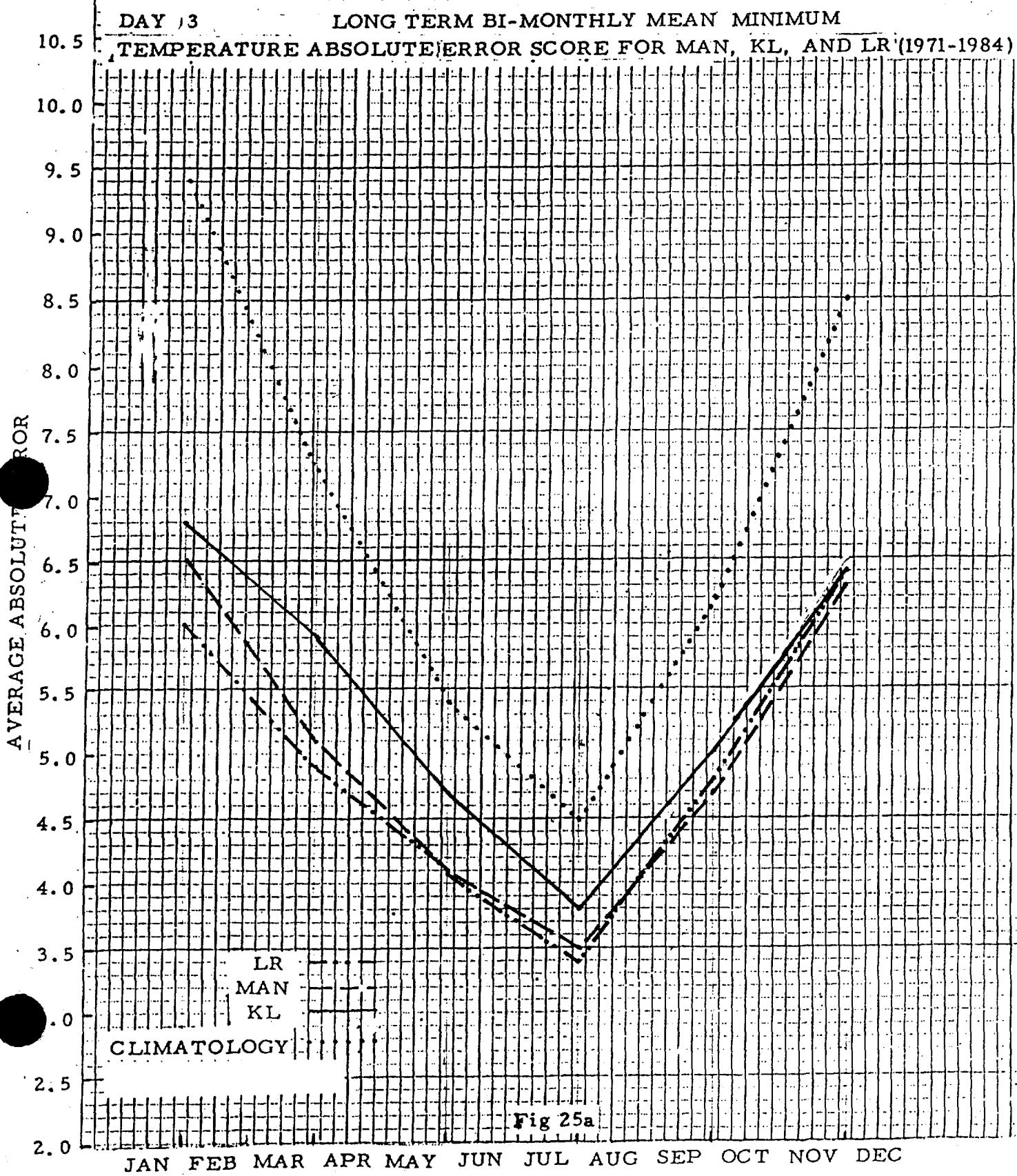


Fig 24a







12.0

11.5

11.0

10.5

10.0

9.5

9.0

8.5

8.0

7.5

7.0

6.5

6.0

5.5

5.0

4.5

4.0

3.5

3.0

2.5

2.0

39

DAY 4

LONG TERM BI-MONTHLY MEAN MINIMUM  
TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR (1971-1984)

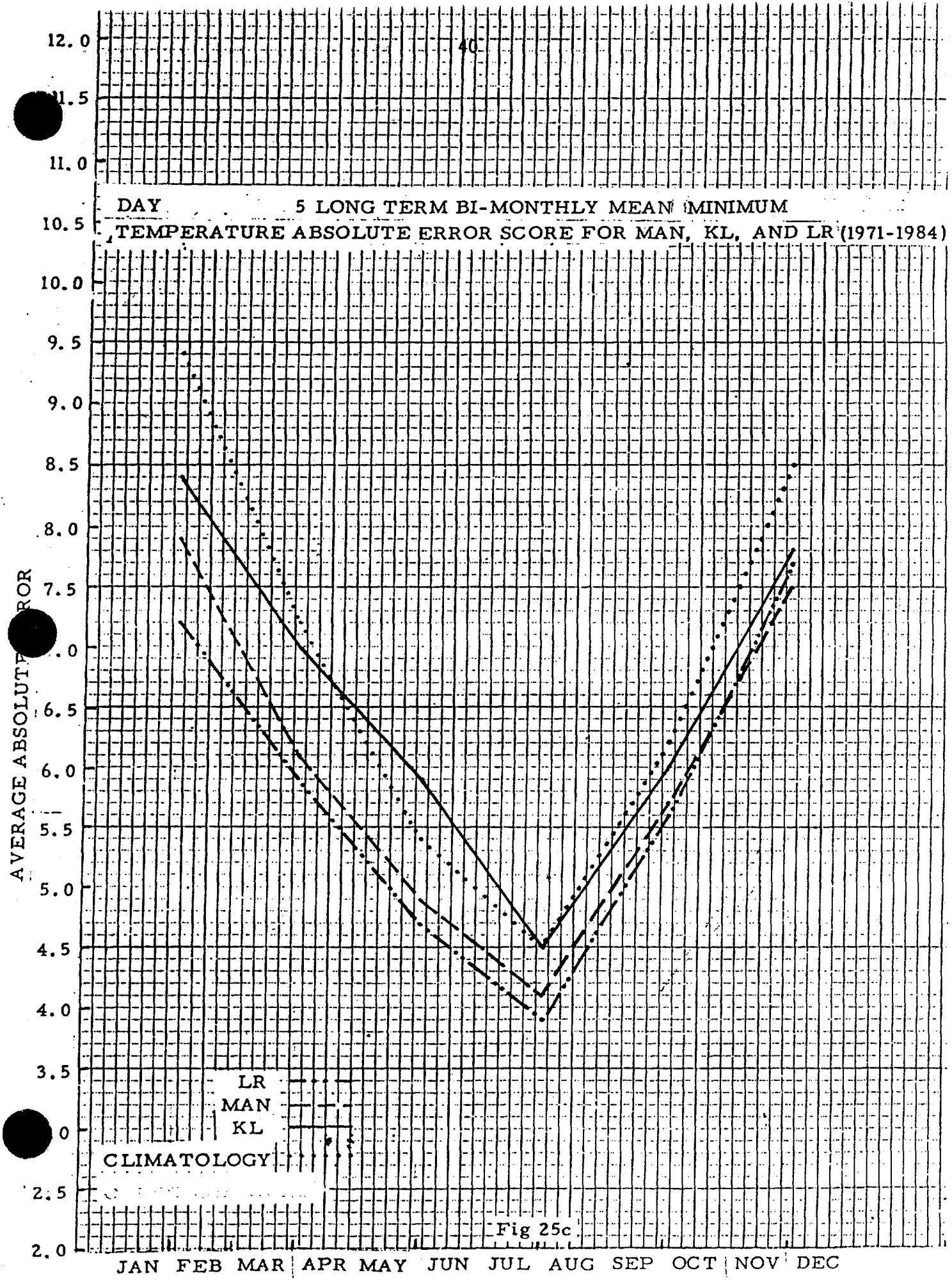
AVERAGE ABSOLUTE ERROR

LR  
MAN  
KL

CLIMATOLOGY

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 25b



DAYS 3, 4, AND 5 BI-MONTHLY MEAN MINIMUM TEMPERATURE ABSOLUTE ERROR SCORES  
FOR MAN AND KL. CALENDAR YEAR AVERAGE

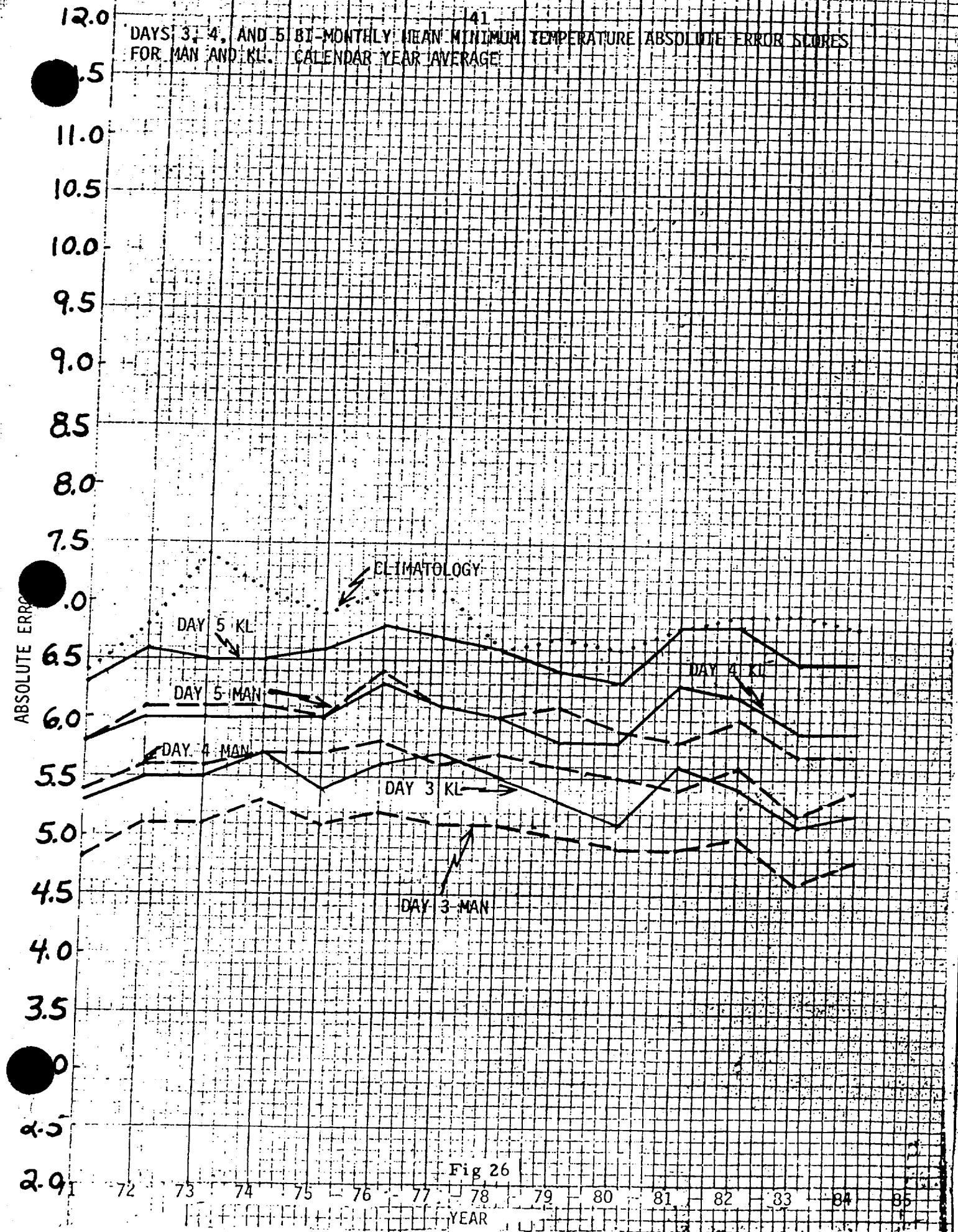
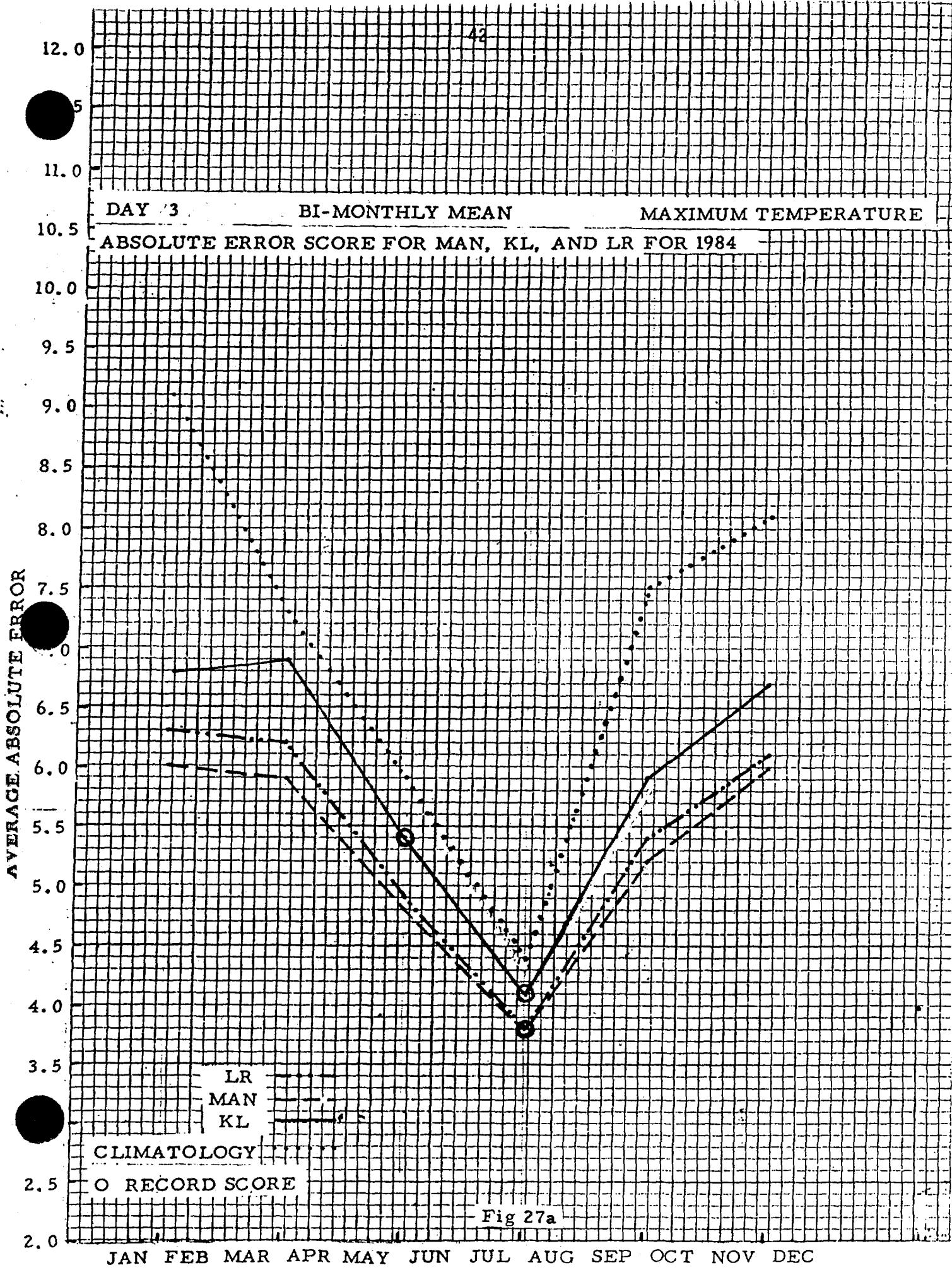
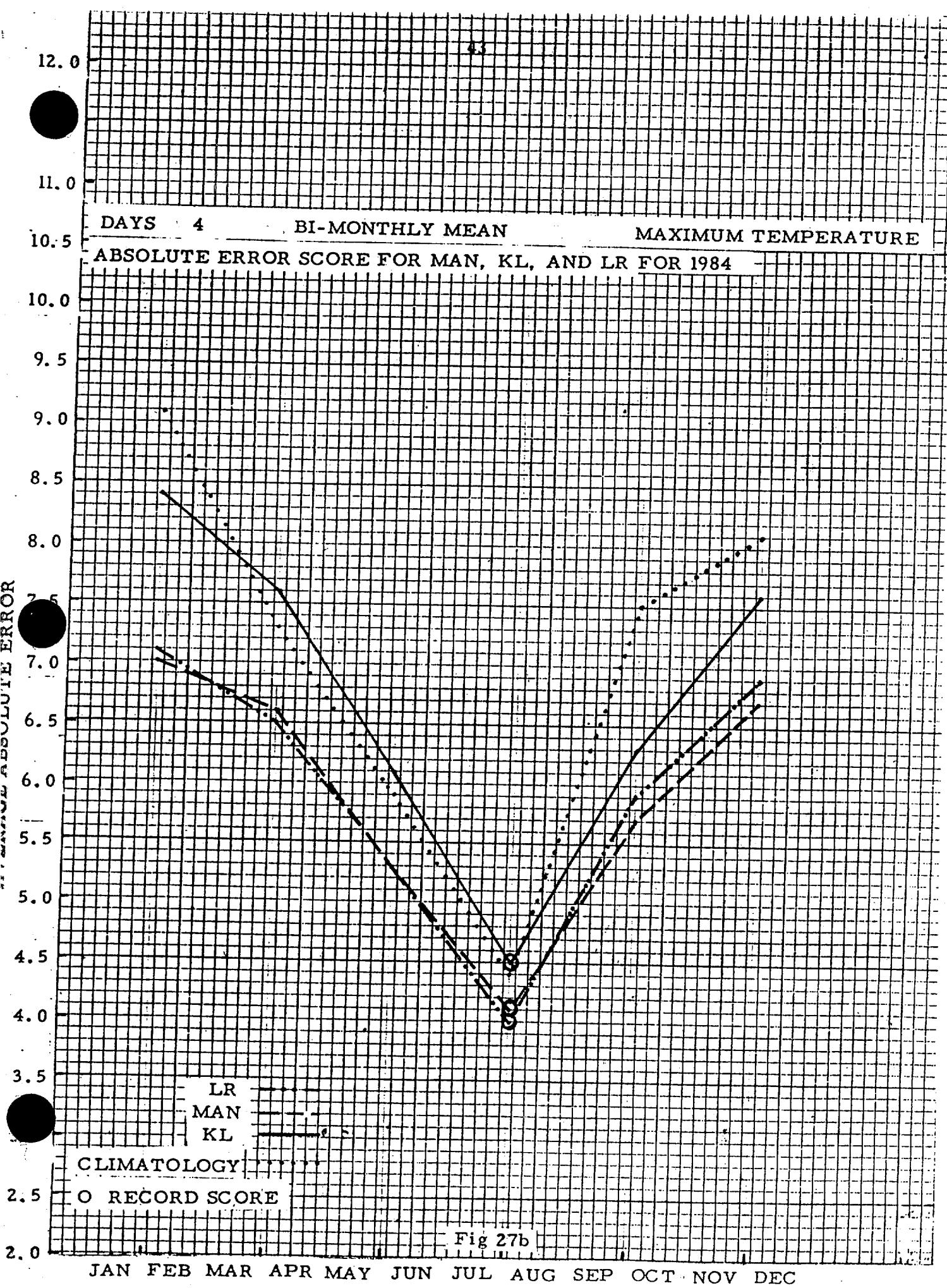
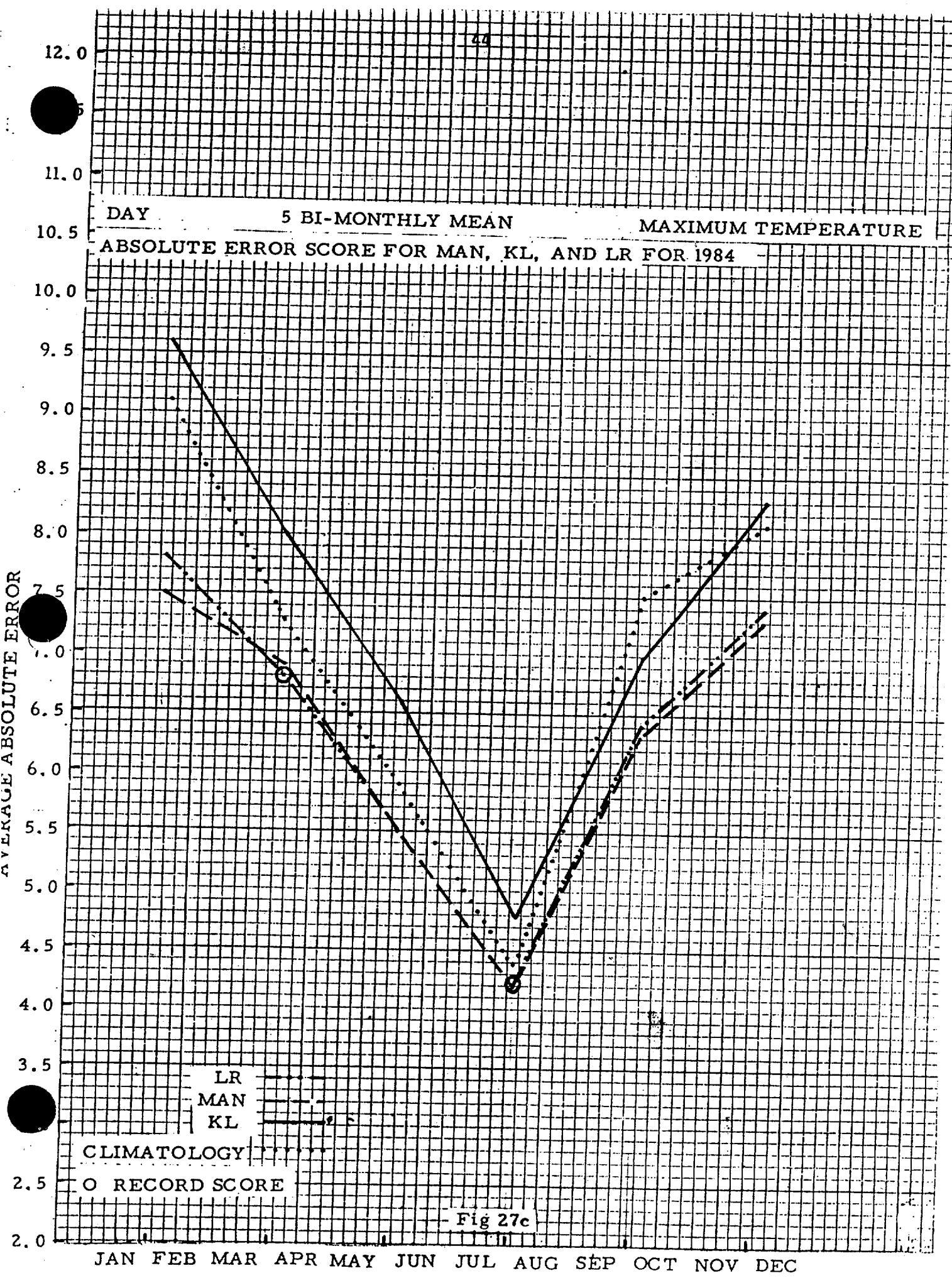


Fig 26







12.0

11.5

11.0

DAY 3

LONG TERM BI-MONTHLY MEAN

MAXIMUM

TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR (1971-1984)

10.0

9.5

9.0

8.5

8.0

AVERAGE ABSOLUTE ERROR

7.5

7.0

6.5

6.0

5.5

5.0

4.5

4.0

3.5

3.0

2.5

2.0

45

LR

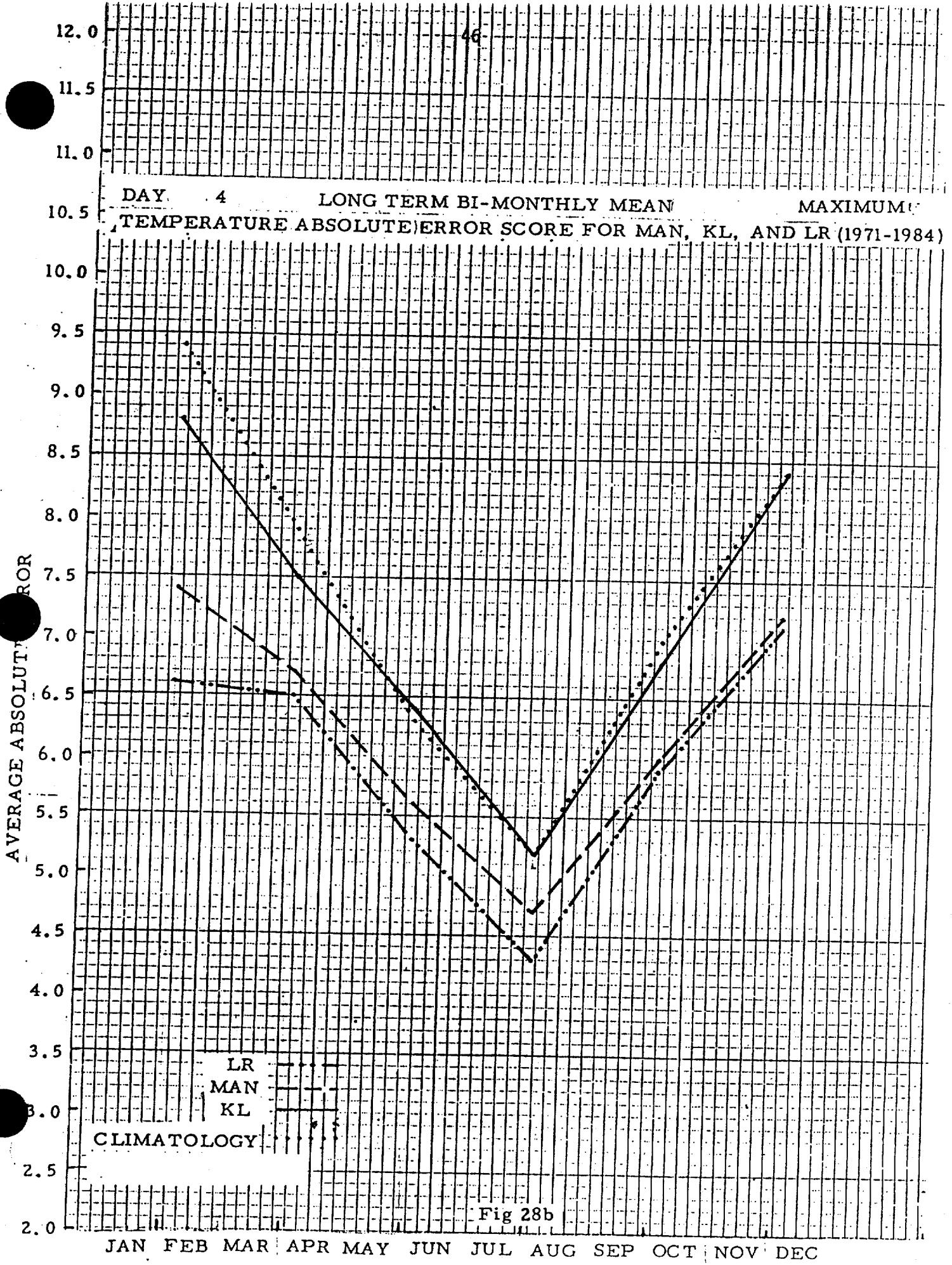
MAN

KL

CLIMATOLOGY

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 28a



12.0

11.5

11.0

DAY

5 LONG TERM BI-MONTHLY MEAN

MAXIMUM

TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR (1971-1984)

10.0

9.5

9.0

8.5

8.0

7.5

7.0

AVERAGE ABSOLUTE ERROR

6.0

5.5

5.0

4.5

4.0

3.5

3.0

LR

MAN

KL

CLIMATOLOGY

47

Fig 28c

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

12.0  
 11.5  
 DAYS 3, 4, AND 5 BI-MONTHLY MEAN MAXIMUM TEMPERATURE ABSOLUTE ERROR  
 SCORES FOR MAN AND KL. CALENDAR YEAR AVERAGE

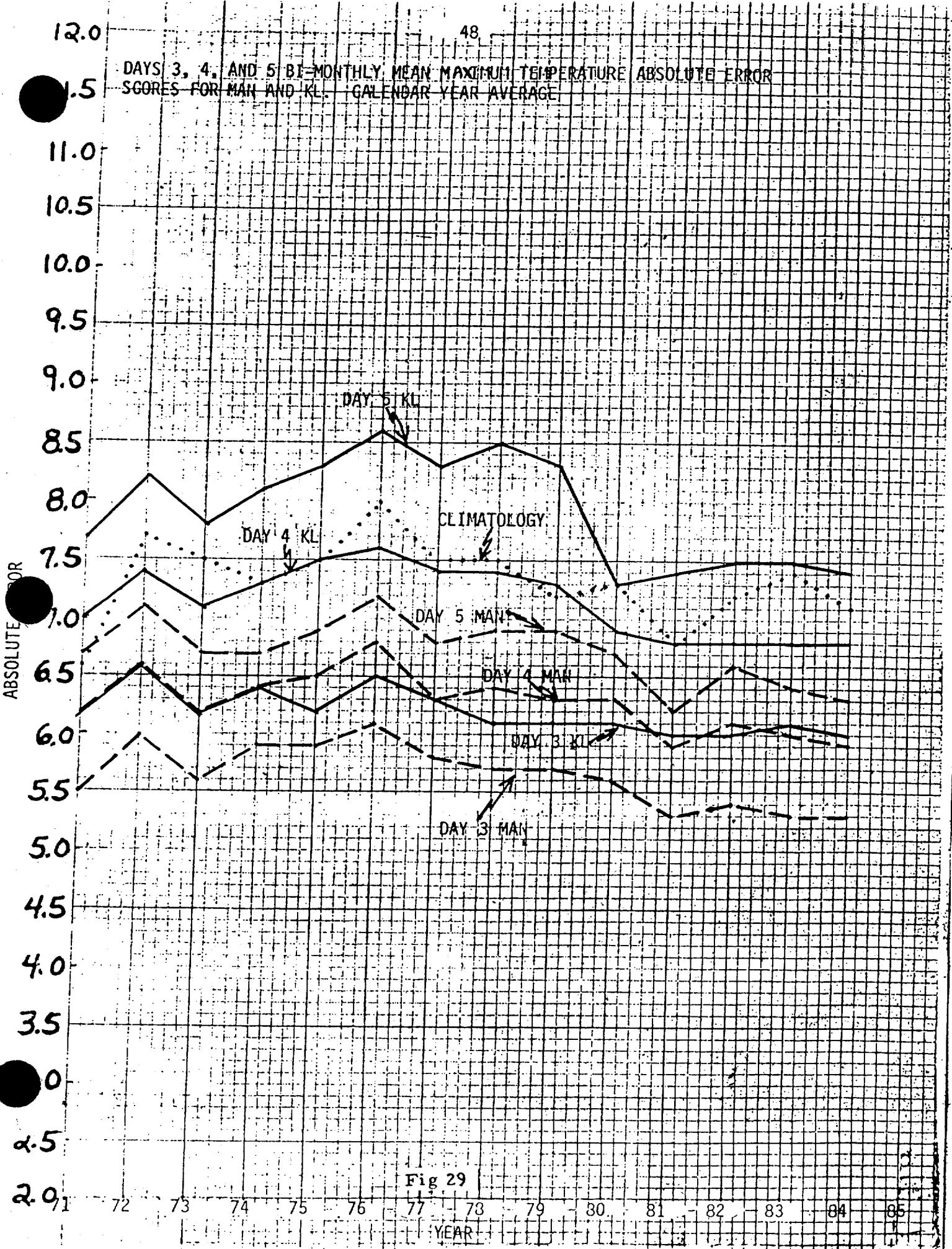


Fig 29

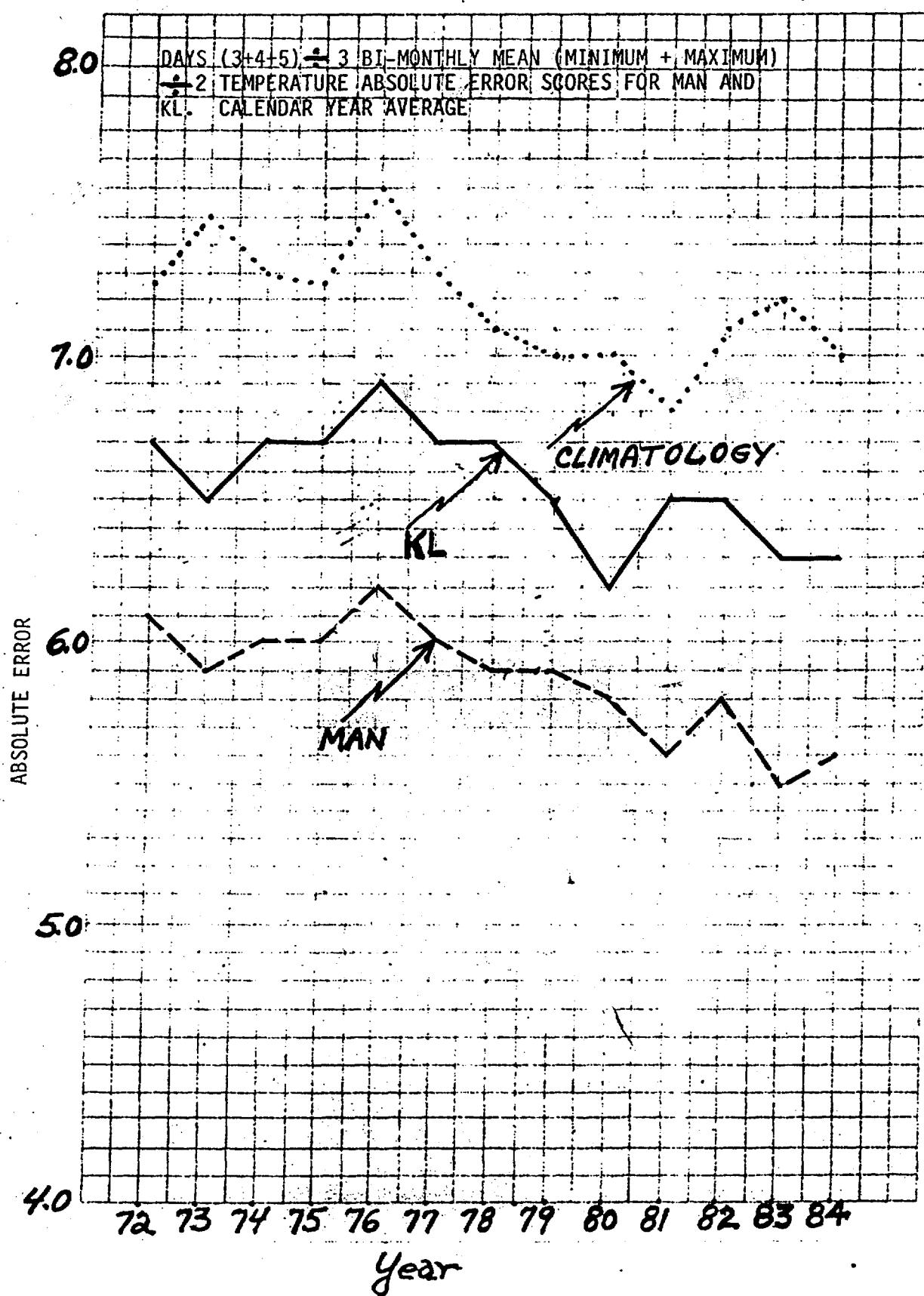


Figure 30

6 TO 10 DAY 5 CLASS MONTHLY MEAN  
TEMPERATURE SKILL SCORE FOR 1984

35

APPROXIMATELY 13 SCORES PER MONTH

30

25

20

15

10

05

00

-05

-10

SKILL SCORE

○ RECORD SCORE

MAN - - - - -

FP - - - - -

LR - - - - -

TOBS - - - - -

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 31

6 TO 10 DAY 5 CLASS LONG TERM MONTHLY MEAN  
TEMPERATURE SKILL SCORES (1978-1984)

35

APPROXIMATELY 13 SCORES PER MONTH

30

25

20

15

SKILL SCORE

10

05

00

-05

-10

MAN - - -

FP - - -

LR - - - -

TOBS - - - -

Fig 32

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

45

52  
6 TO 10 DAY CALENDAR YEAR AVERAGE  
5 CLASS MONTHLY MEAN TEMPERATURE  
SKILL SCORES FOR 1978 - 1984

APPROXIMATELY 13 CASES PER MONTH

40

35

30

25

SKILL SCORE

10

5

MAN ——  
LR ·····  
FP ——  
TOBS ····

-5

76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97

Fig 33

6 TO 10 DAY 3 CLASS MONTHLY MEAN  
TEMPERATURE SKILL SCORE FOR 1984

53

APPROXIMATELY 13 SCORES PER MONTH

40

35

30

25

20

15

10

5

SKILL SCORE

O RECORD SCORE

MAN -----

FP -----

LR ..... .

TOBS ..... .

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 34

-3 -7

54  
6 TO 10 DAY 3 CLASS LONG TERM MONTHLY MEAN  
TEMPERATURE SKILL SCORES (1978-1984)

APPROXIMATELY 13 SCORES PER MONTH

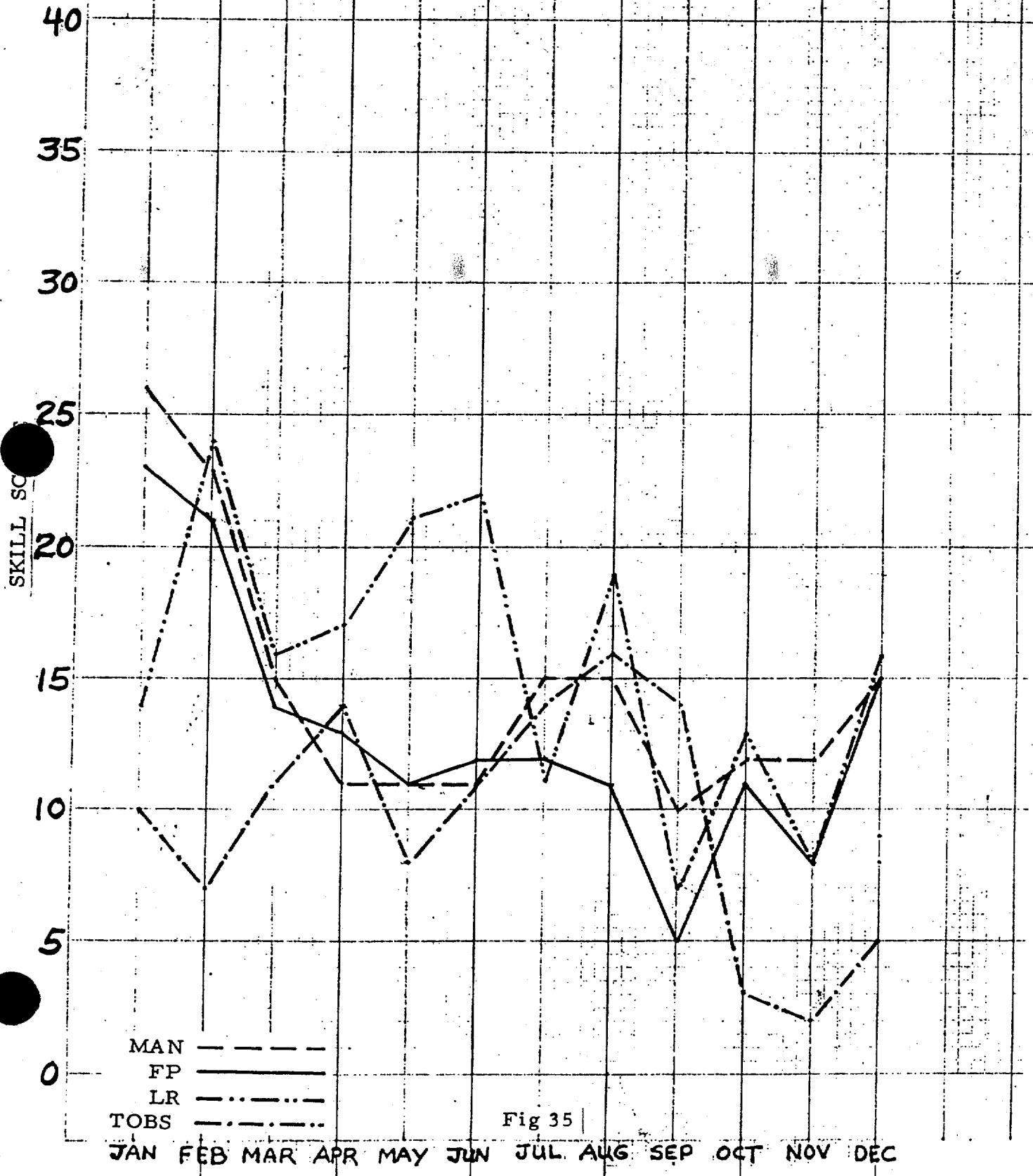


Fig 35

55  
45  
6 TO 10 DAY CALENDAR YEAR AVERAGE  
3 CLASS MONTHLY MEAN TEMPERATURE  
SKILL SCORES FOR 1978 - 1984

40  
35  
30  
25  
20  
15  
10  
5  
-5  
APPROXIMATELY 13 CASES PER MONTH

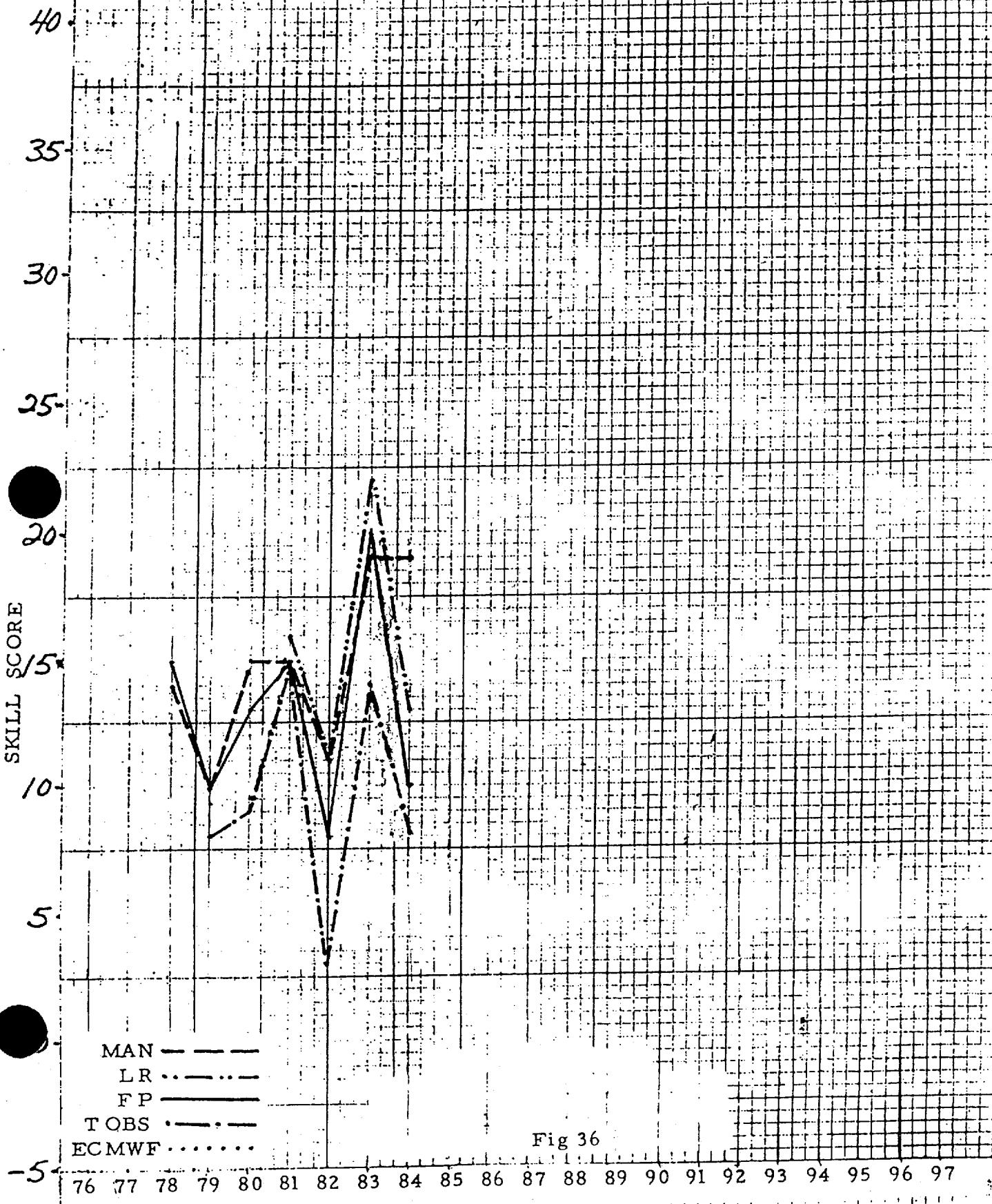


Fig 36

**SECTION 3**  
**Man & Climatology**  
**Precipitation Skill Scores**

PRECIPITATION  
VERIFICATION STATIONS  
BASIC WEATHER ELEMENTS

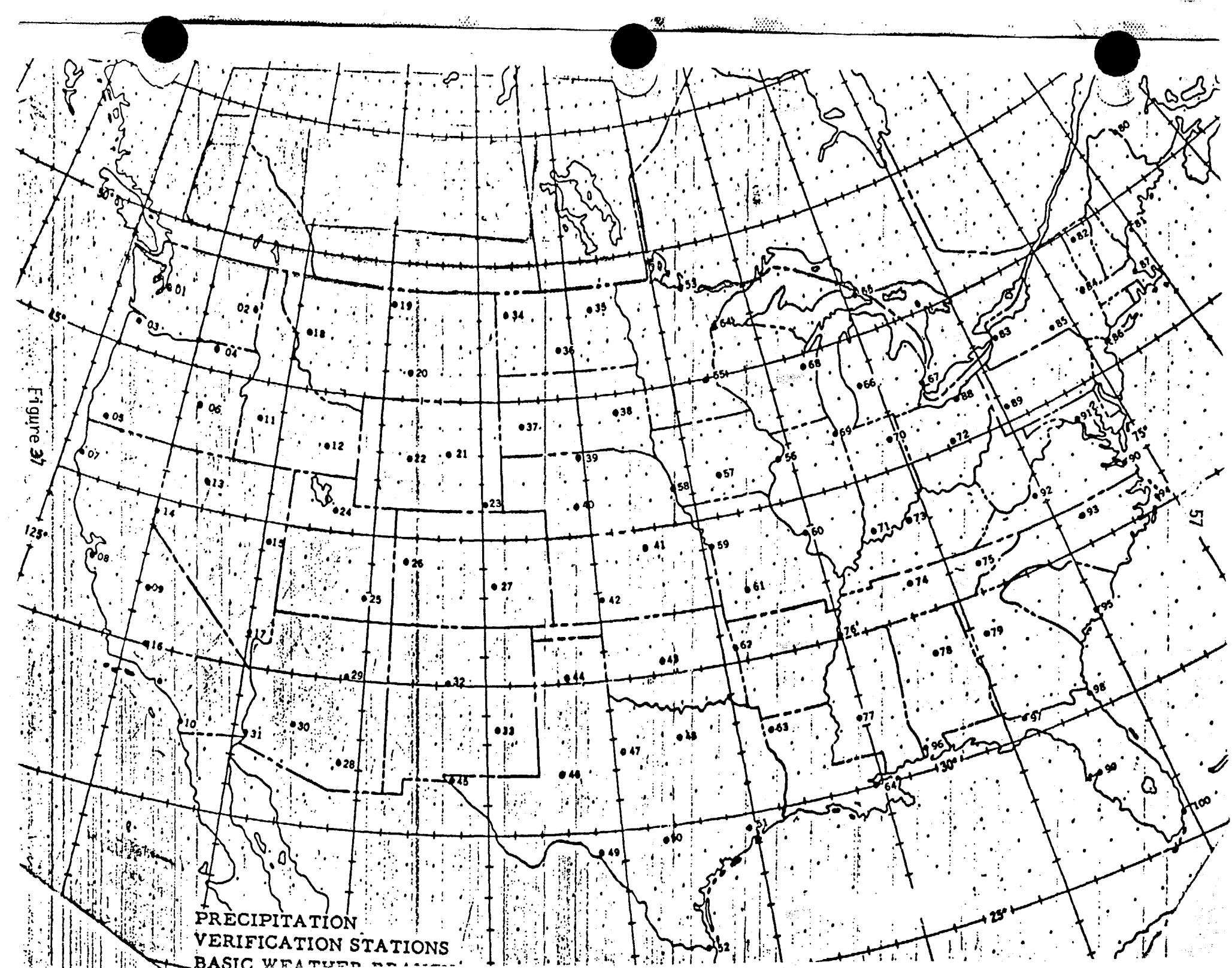


Figure 37

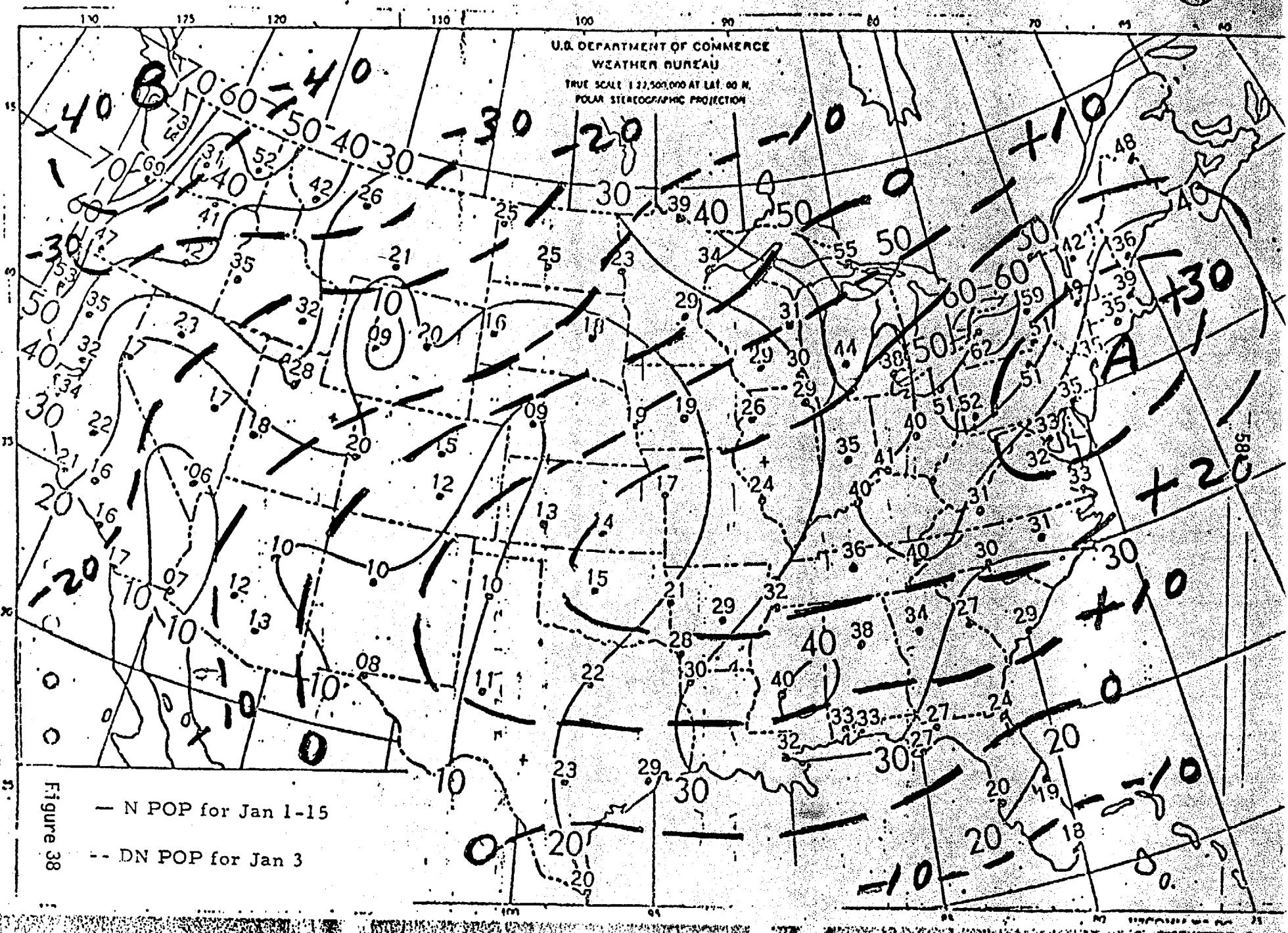


Figure 38

40

DAYS 3, 4, AND 5 MONTHLY MEAN GILMAN PRECIPITATION  
SKILL SCORES FOR 1984

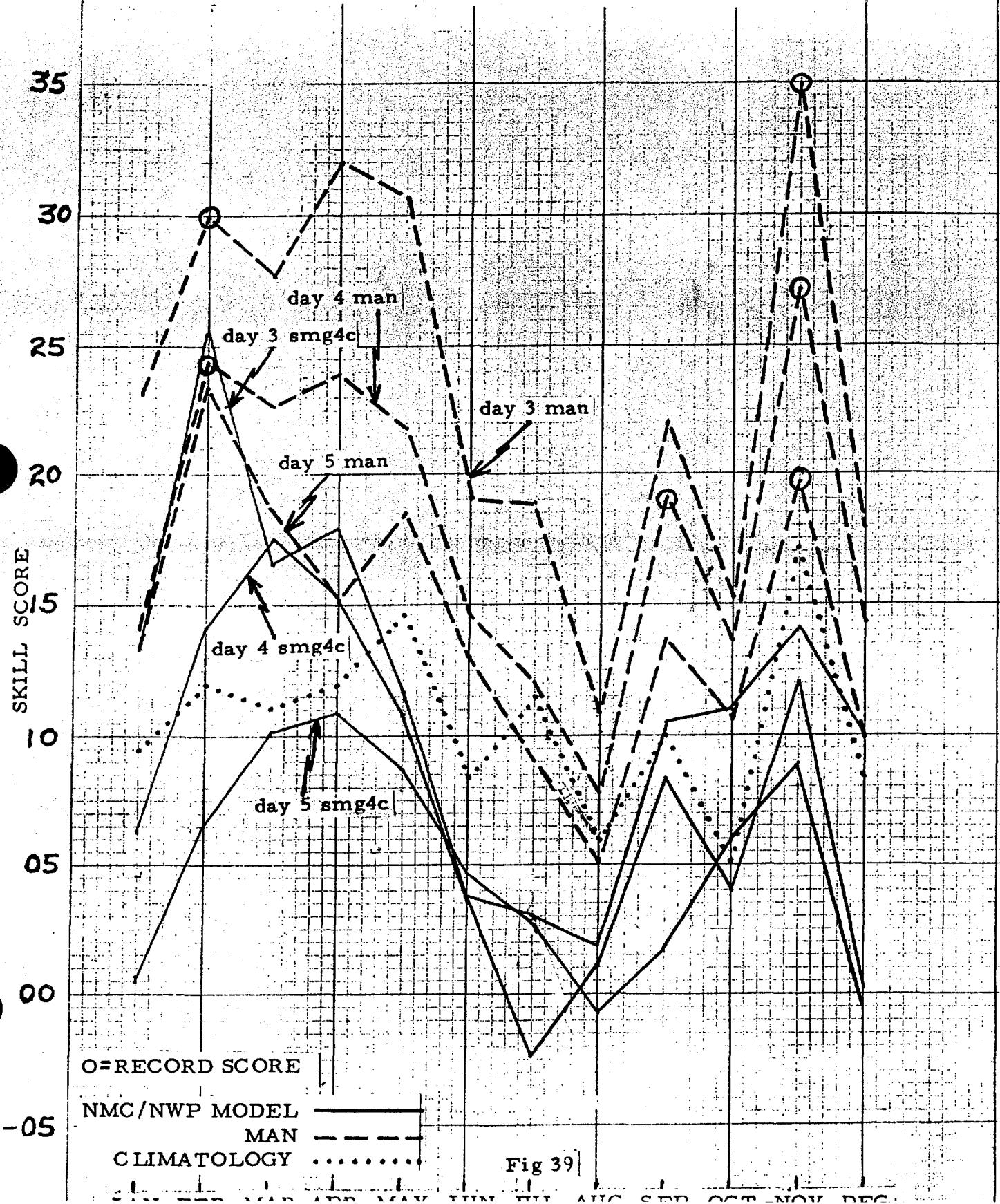
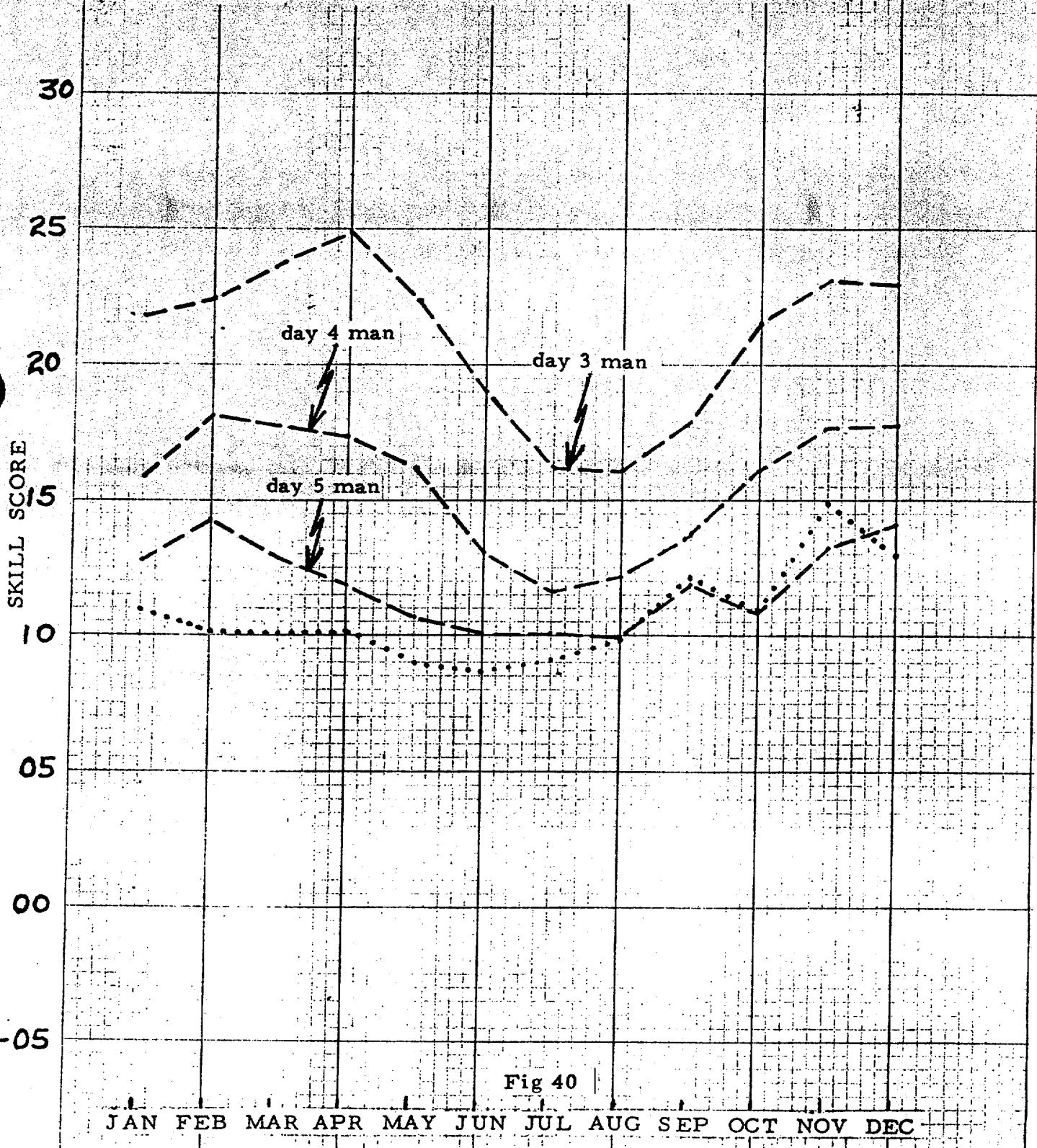


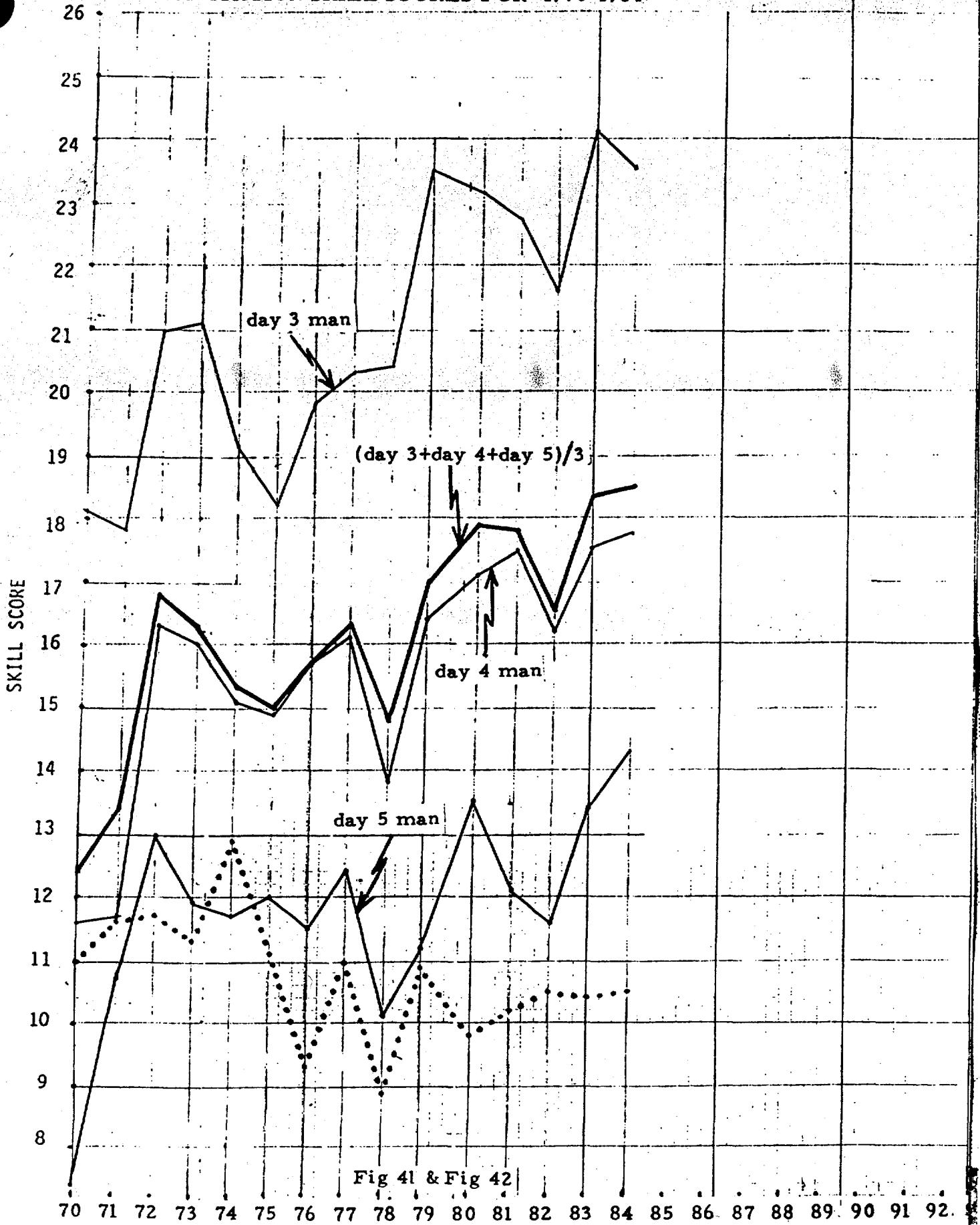
Fig 39

60  
40  
35  
30  
25  
20  
15  
10  
05  
00  
-05

DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN GILMAN  
PRECIPITATION SKILL SCORES FOR 1970-1984



27  
 DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE GILMAN  
 PRECIPITATION SKILL SCORES FOR 1970-1984



40 DAYS 3, 4, AND 5 MONTHLY MEAN HUGHES PRECIPITATION  
SKILL SCORES FOR 1984

O=RECORD SCORE

NMC/NWP MODEL

MAN  
CLIMATOLOGY

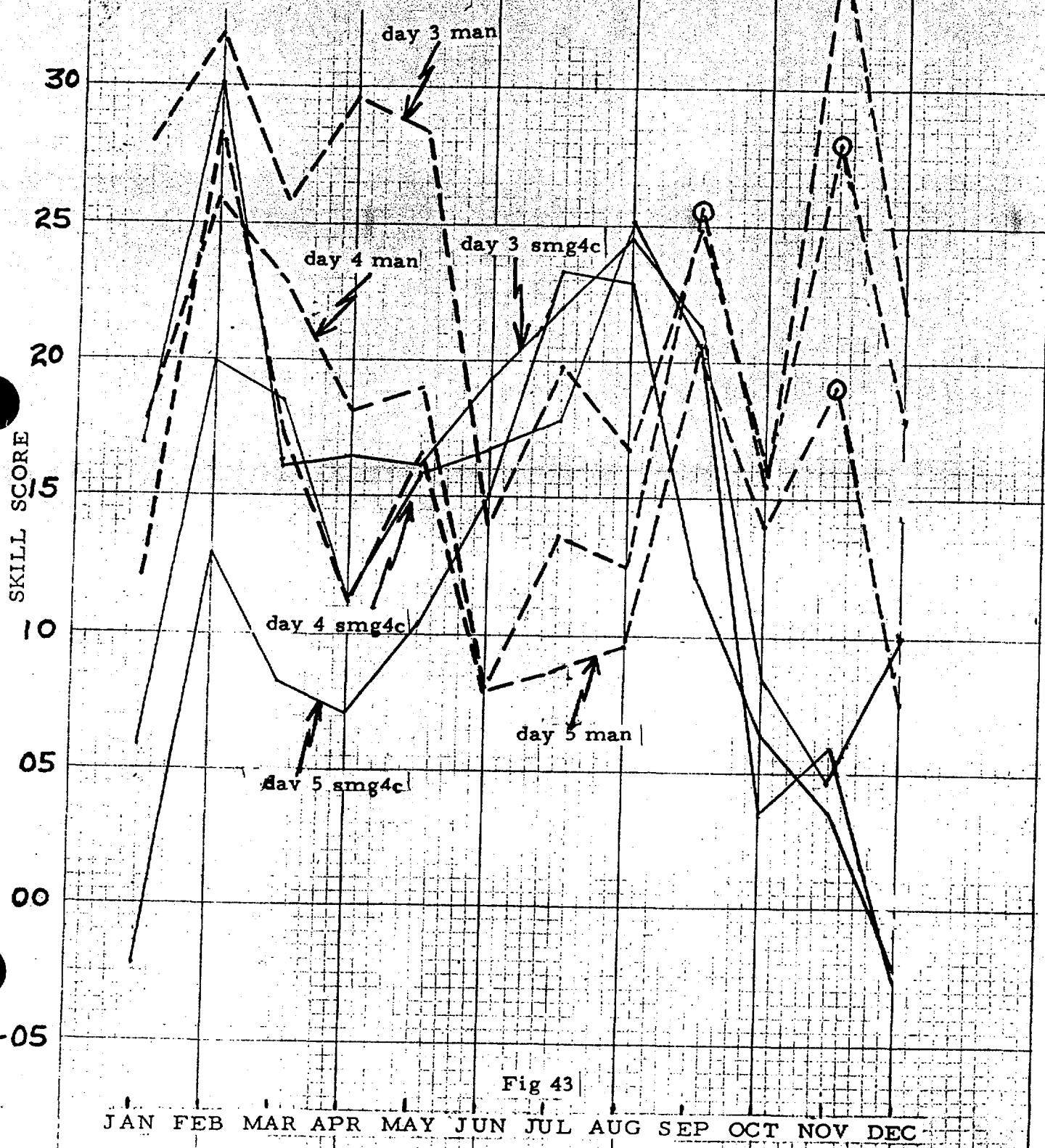


Fig 43

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

63

40

35

30

25

20

15

10

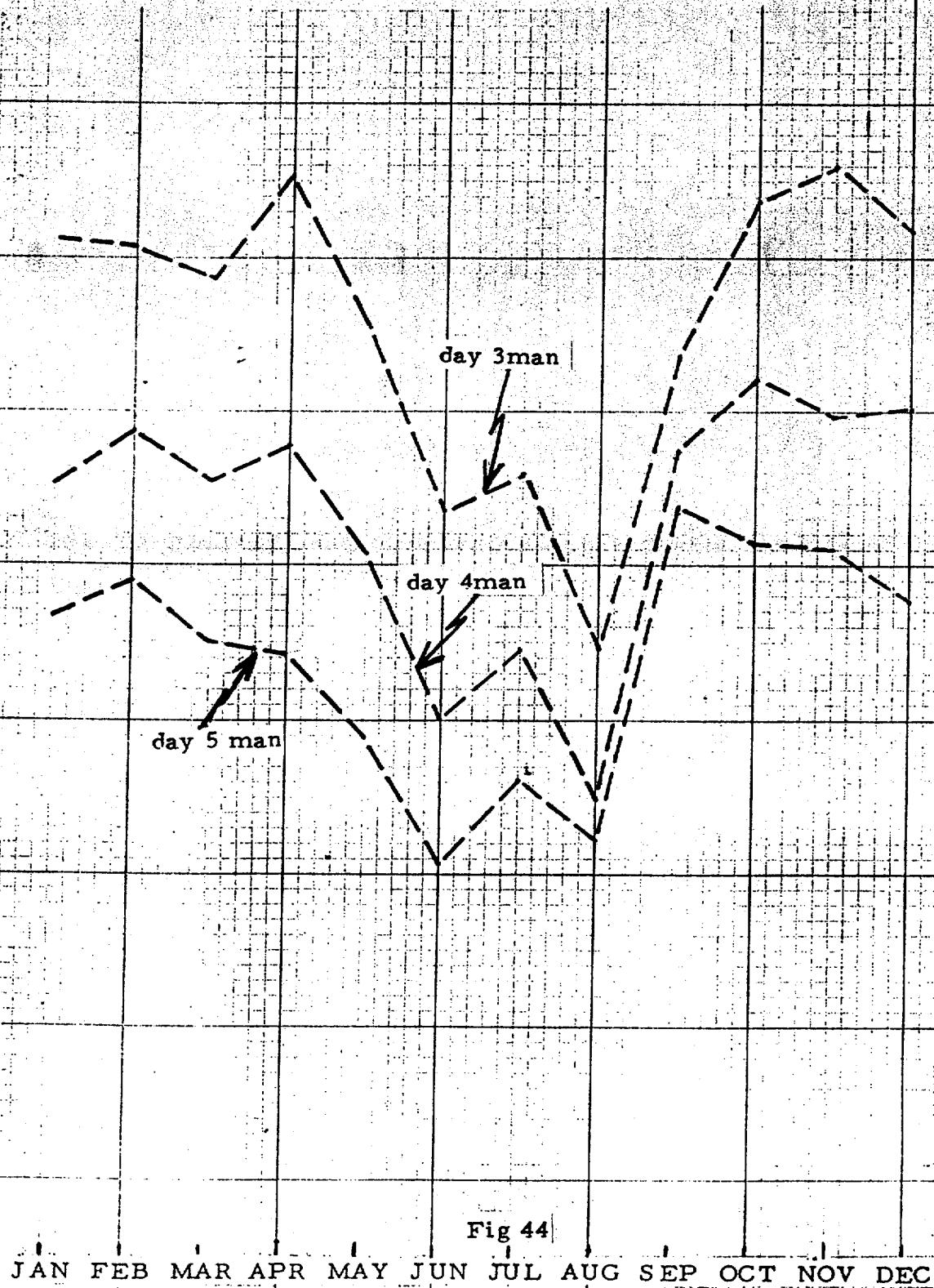
05

00

-05

SKILL SCORE

DAY 3, 4, AND 5 LONG TERM MONTHLY MEAN HUGHES  
PRECIPITATION SKILL SCORES FOR 1977-1984



40

54

DAYS 3, 4, AND 5 CALENDAR-YEAR AVERAGE HUGHES  
PRECIPITATION SKILL SCORES FOR 1977-1984

35

30

25

20

SKILL SCORE

15

10

05

00

-05

77 78 79 80 81 82 83 84 85 86 87 88 89 90 91

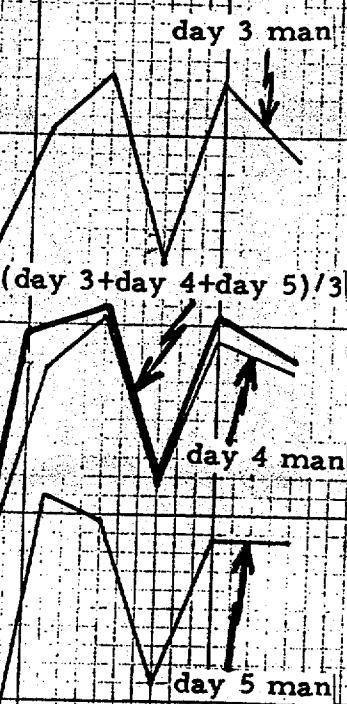


Fig 45

DAY 3, 4, AND 5 MONTHLY MEAN HUGHES PRECIPITATION  
PROBABILITY SKILL SCORES FOR 1984

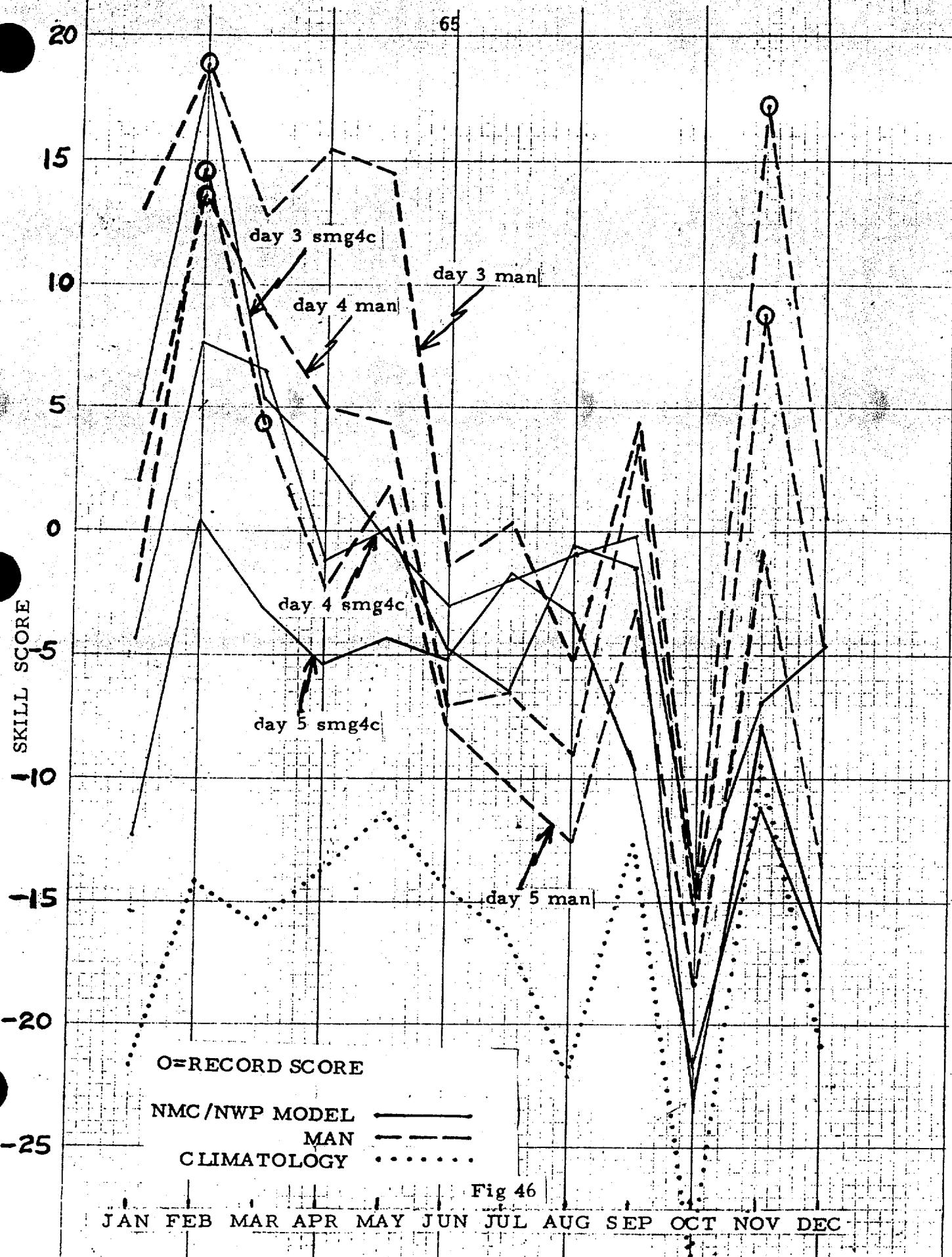


Fig 46

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

20

15

10

5

0

SKILL SCORE

-5

-10

-15

-20

-25

DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN HUGHES  
PROBABILITY PRECIPITATION SKILL SCORES FOR 1978-1984

day 5 man

day 3 man

day 4 man

climatology

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 47

20 DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE HUGHES  
PROBABILITY PRECIPITATION SKILL SCORES FOR 1978-1984

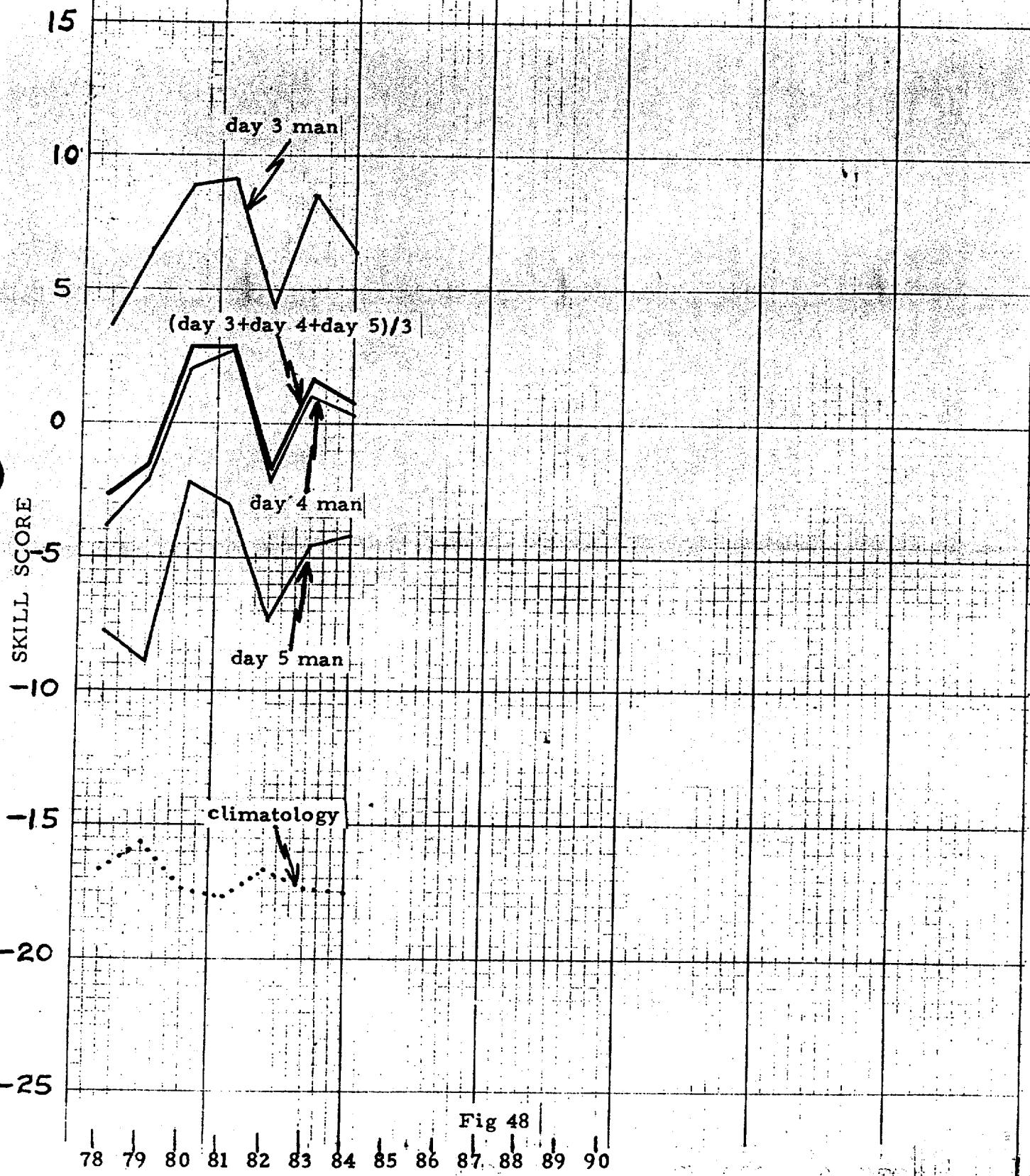


Fig 48

45

1 TO 5 DAY 3 CLASS MONTHLY MEAN  
PRECIPITATION SKILL SCORES FOR 1984

68

40.

35.

30.

25.

20.

SKILL SCORE

10.

5.

0.

-5.

O RECORD SCORE

MAN - - -

NMC/NWP MODEL - - - -

CLIMATOLOGY .....

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig 49

45

I TO 5 DAY 3 CLASS LONG TERM MONTHLY MEAN  
PRECIPITATION SKILL SCORES (1978-1984)

40

35

30

25

20

15

10

5

SKILL SCORE

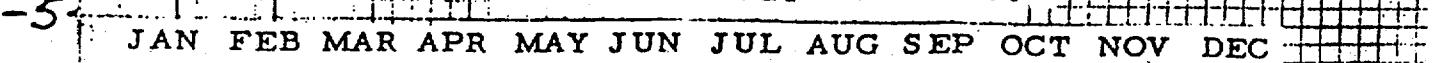
-5

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

MAN - - -

Fig 50

CLIMATOLOGY . . . . .



1 TO 5 DAY CALENDAR YEAR AVERAGE  
3-CLASS MONTHLY MEAN PRECIPITATION  
SKILL SCORES FOR 1978 - 1984

APPROXIMATELY 13 CASES PER MONTH

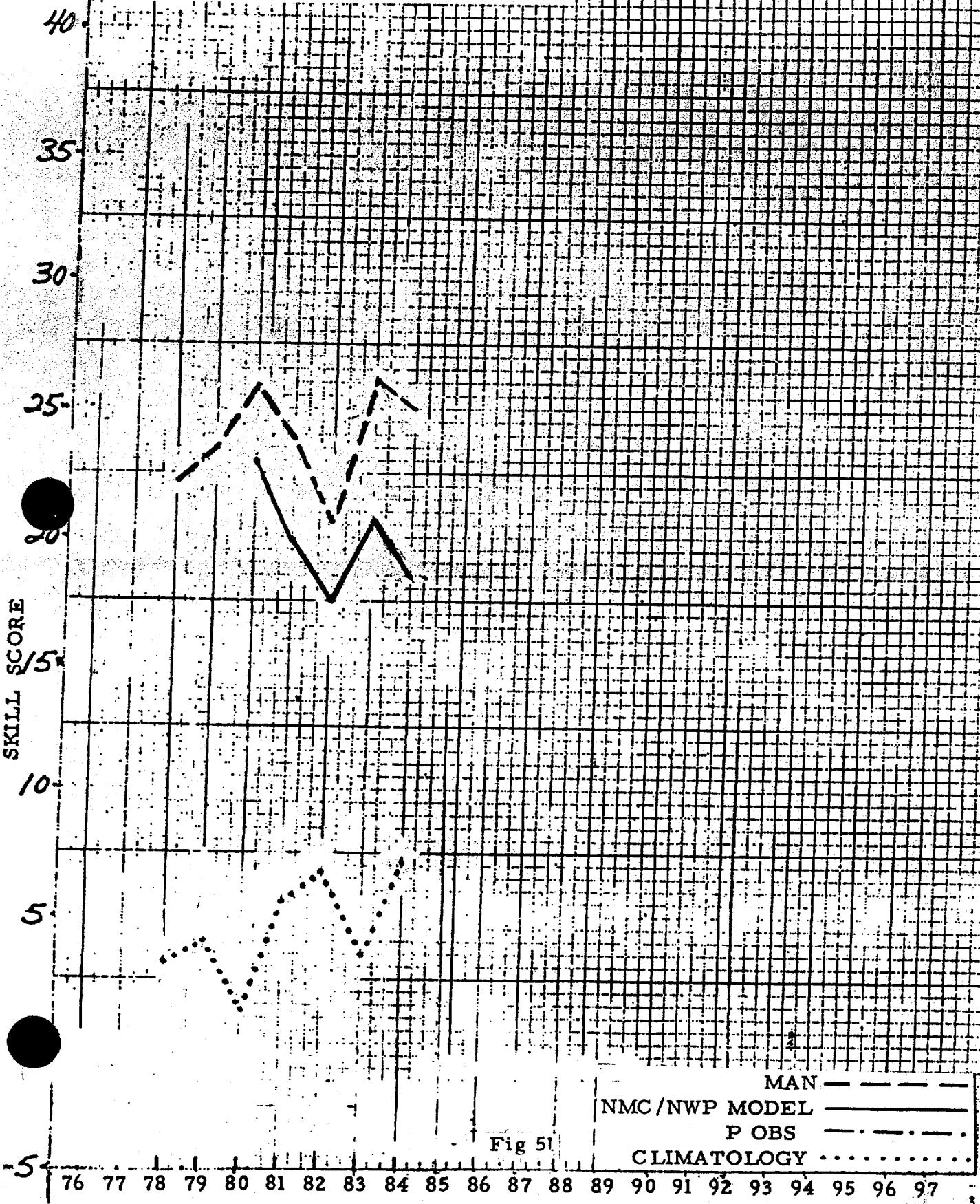


Fig 51

45- 6 TO 10 DAY 3-CLASS MONTHLY MEAN  
PRECIPITATION SKILL SCORES FOR 1984

APPROXIMATELY 13 CASES PER MONTH

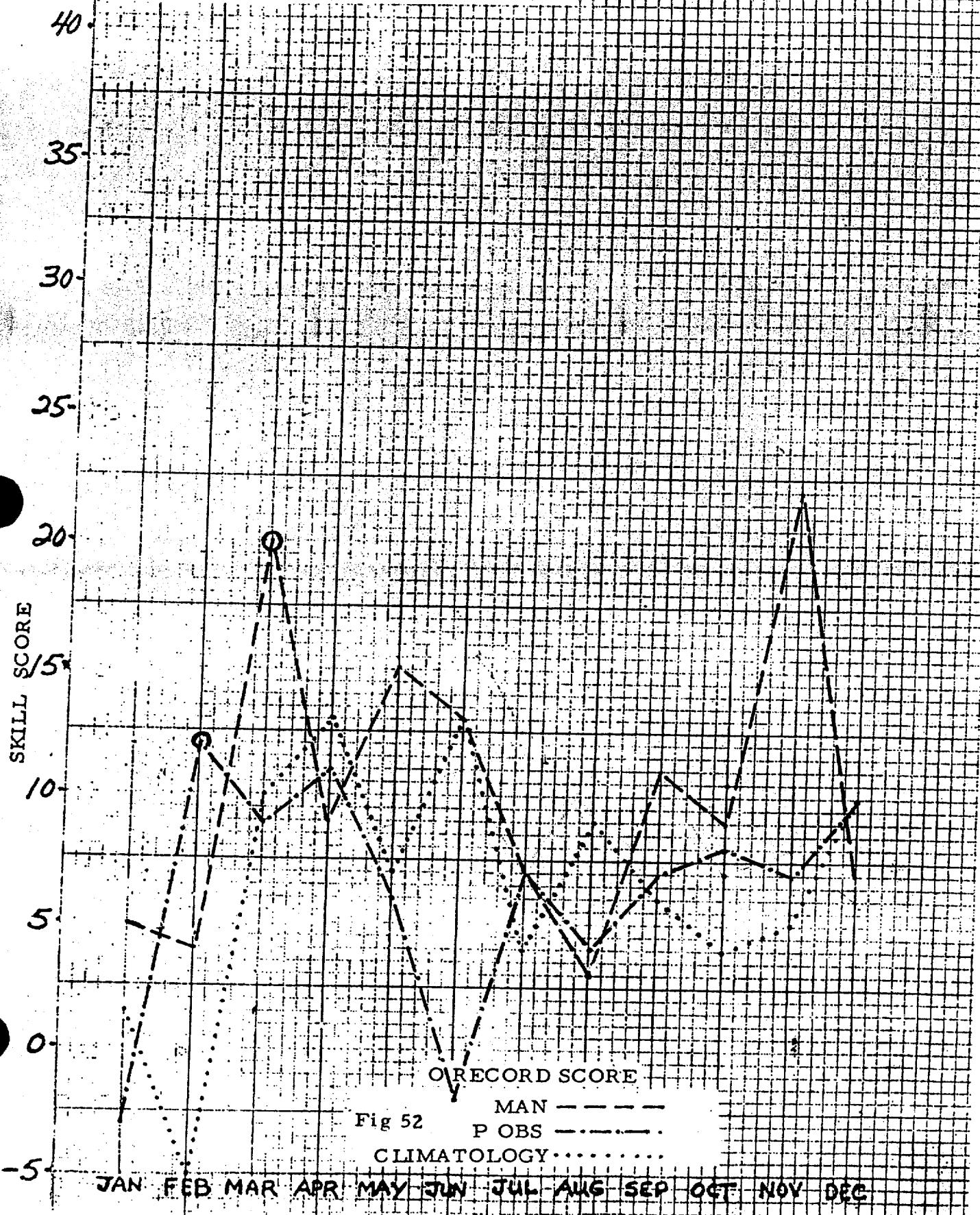
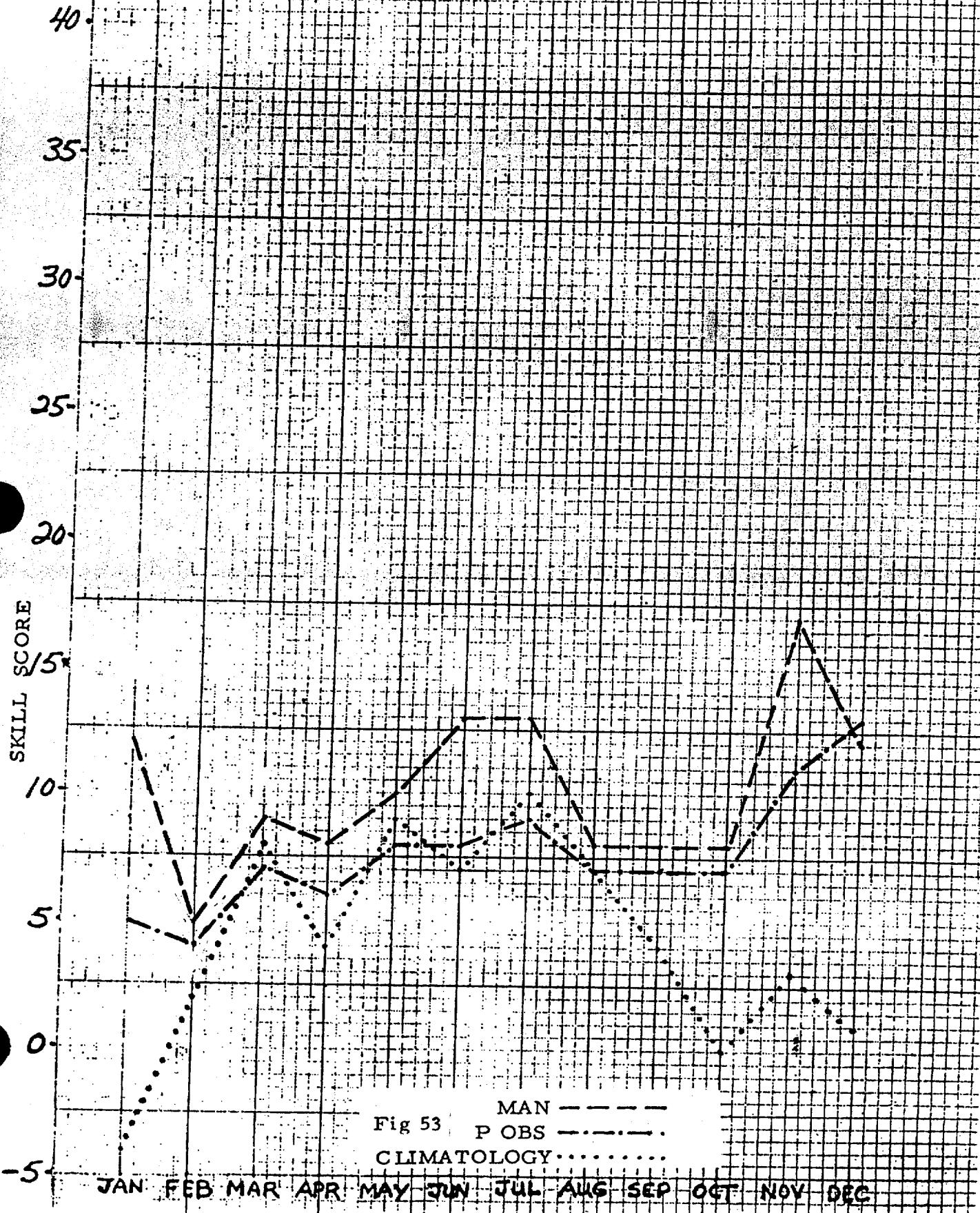


Fig 52  
MAN ——  
P OBS - - . . .  
CLIMATOLOGY · · · · ·

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

45  
6 TO 10 DAY 3-CLASS LONG TERM MONTHLY MEAN  
PRECIPITATION SKILL SCORES (1978-1984)

APPROXIMATELY 13 CASES PER MONTH



73  
45 6 TO 10 DAY CALENDAR YEAR AVERAGE  
3-CLASS MONTHLY MEAN PRECIPITATION  
SKILL SCORES FOR 1978 - 1984

APPROXIMATELY 13 CASES PER MONTH

40.

35

30

25

20

15

10

5

SKILL SCORE

-5

76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97

MAN -----

NMC / NWP MODEL - - - - -

P OBS - - - - -

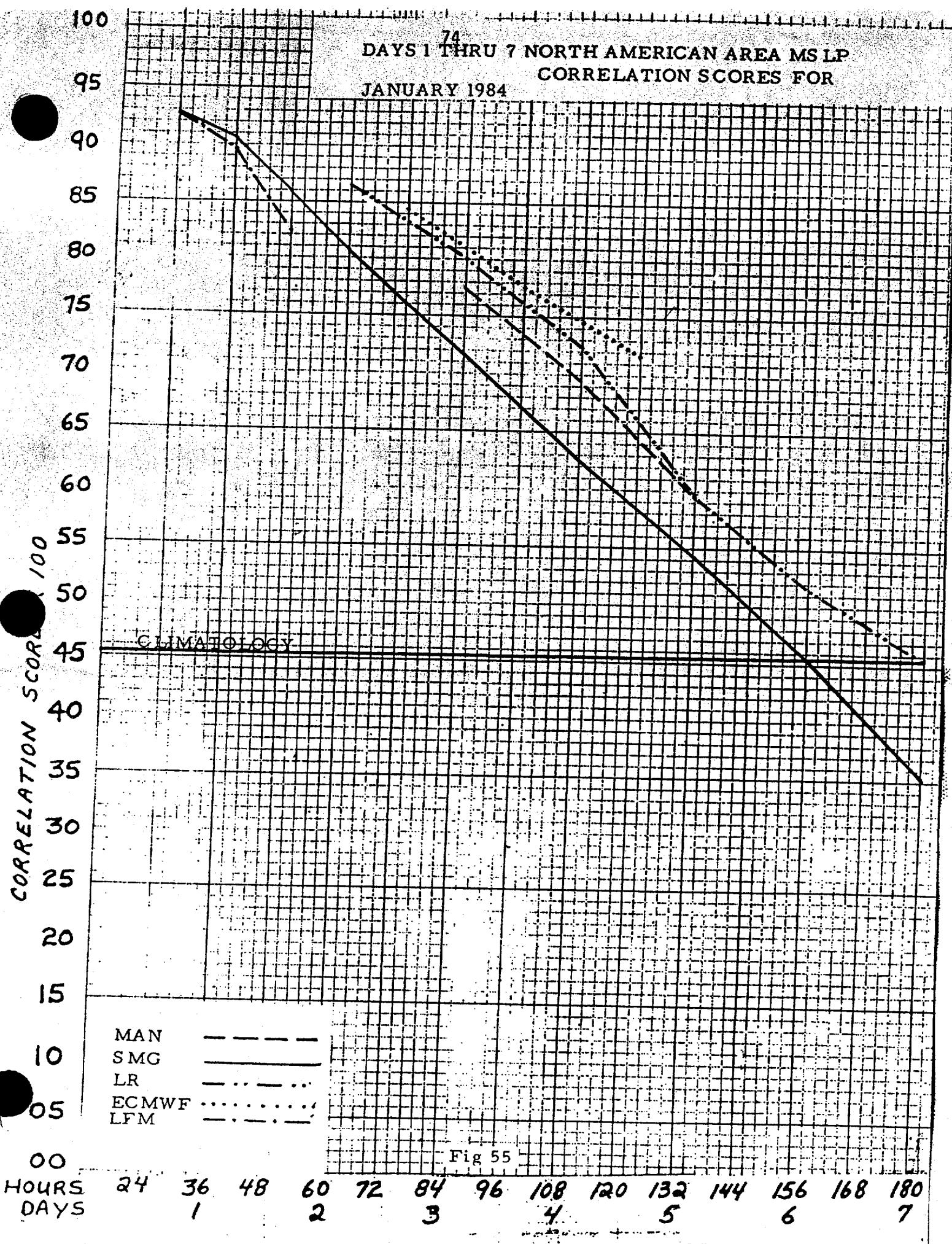
CLIMATOLOGY . . . . .

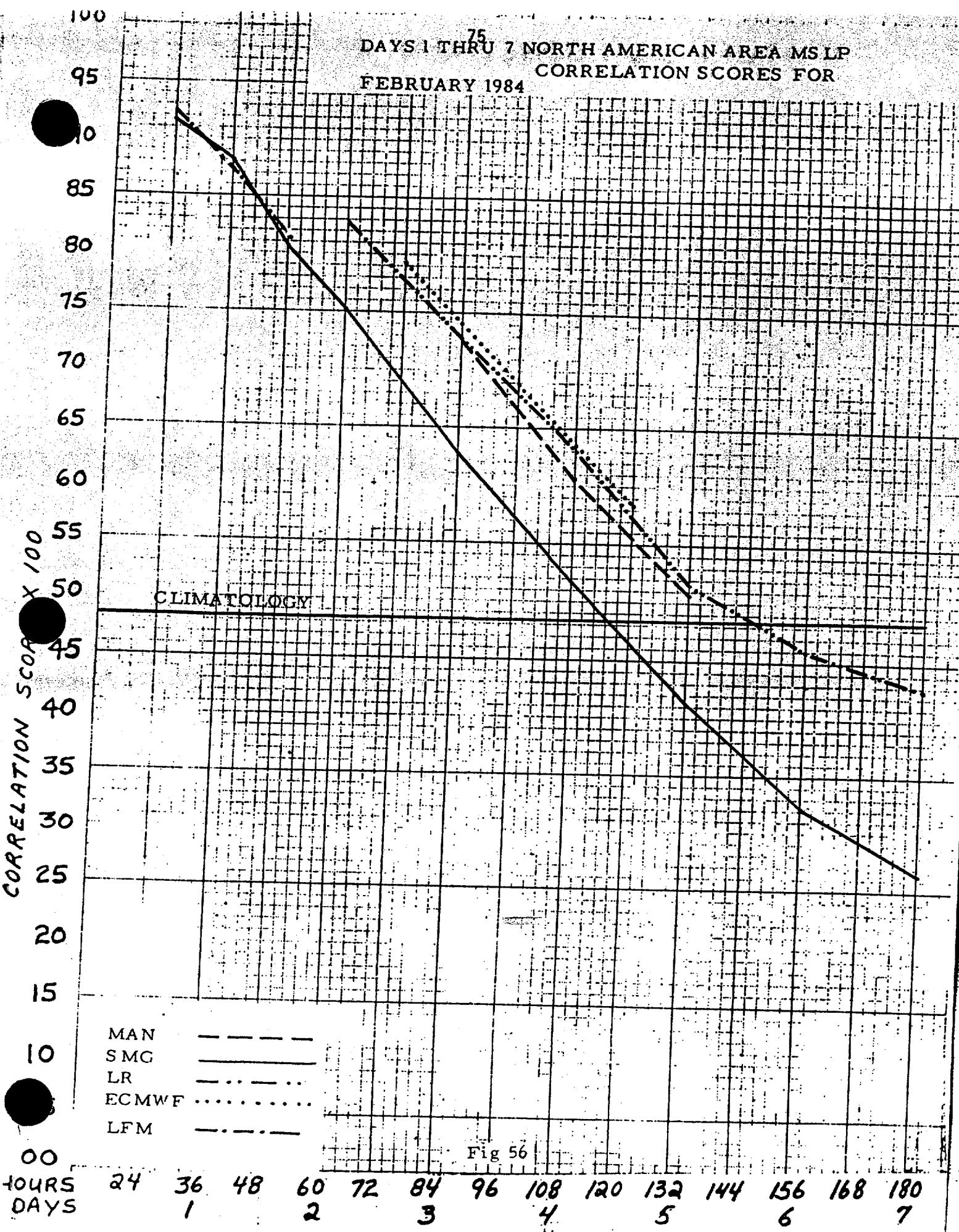
Fig 54

## **SECTION 4**

**Man & Machine (NMC/NWP Guidance)**

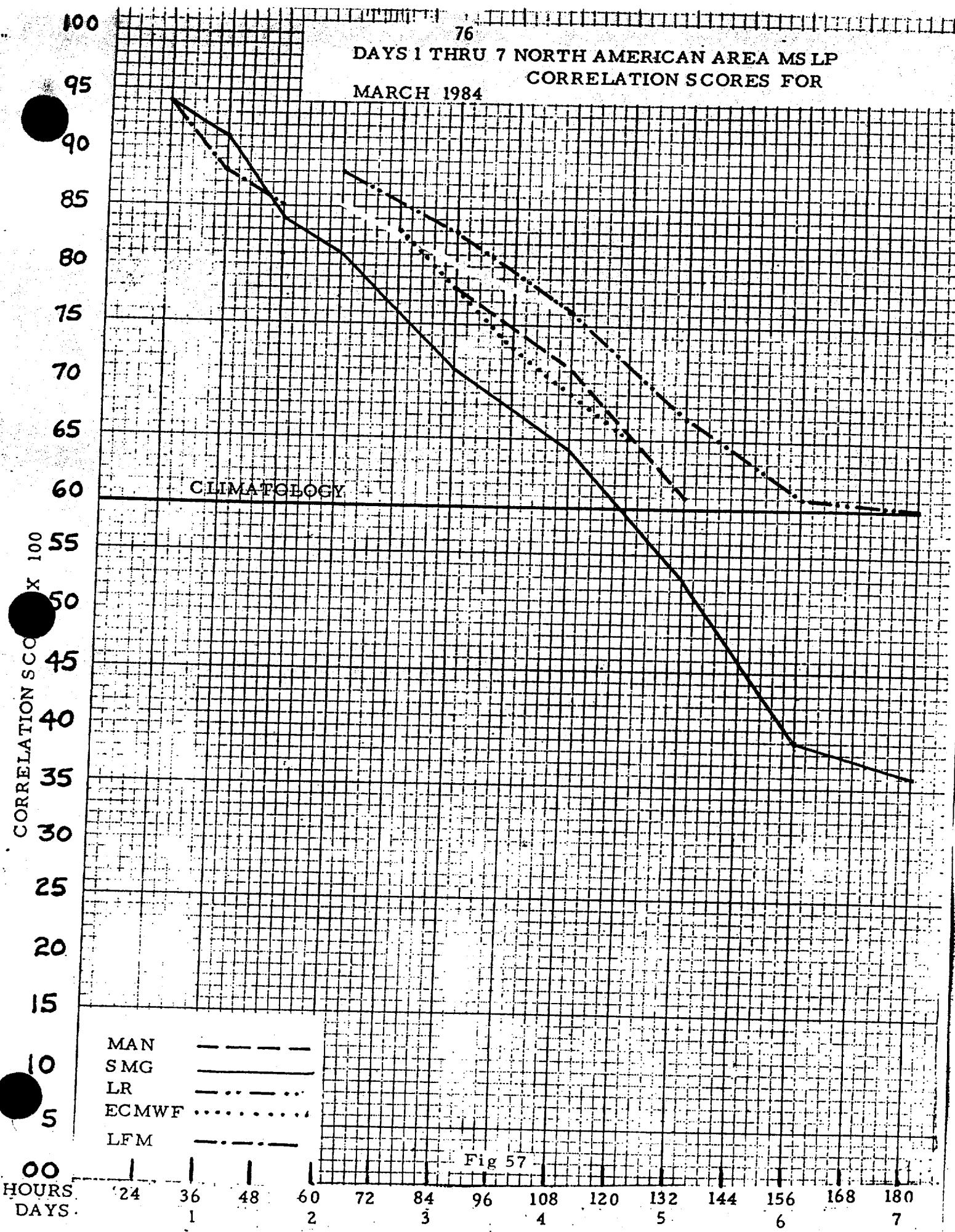
**Days 1 through 7 Monthly Mean Sea Level Pressure, 500 MB and  
Absolute Error Temperature Scores**





76  
DAYS 1 THRU 7 NORTH AMERICAN AREA MSLP  
CORRELATION SCORES FOR

MARCH 1984



100

95

90

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

05

00

CORRELATION SCORE X 100

77

DAYS 1 THRU 7 NORTH AMERICAN AREA MS LP  
APRIL 1984 CORRELATION SCORES FOR

CLIMATOLOGY

MAN

SMG

LR

ECMWF

LFM

DAY 8 = 6

DAY 9 = 3

Fig 58

HOURS  
DAYS

24

36

48

60

72

84

96

108

1

2

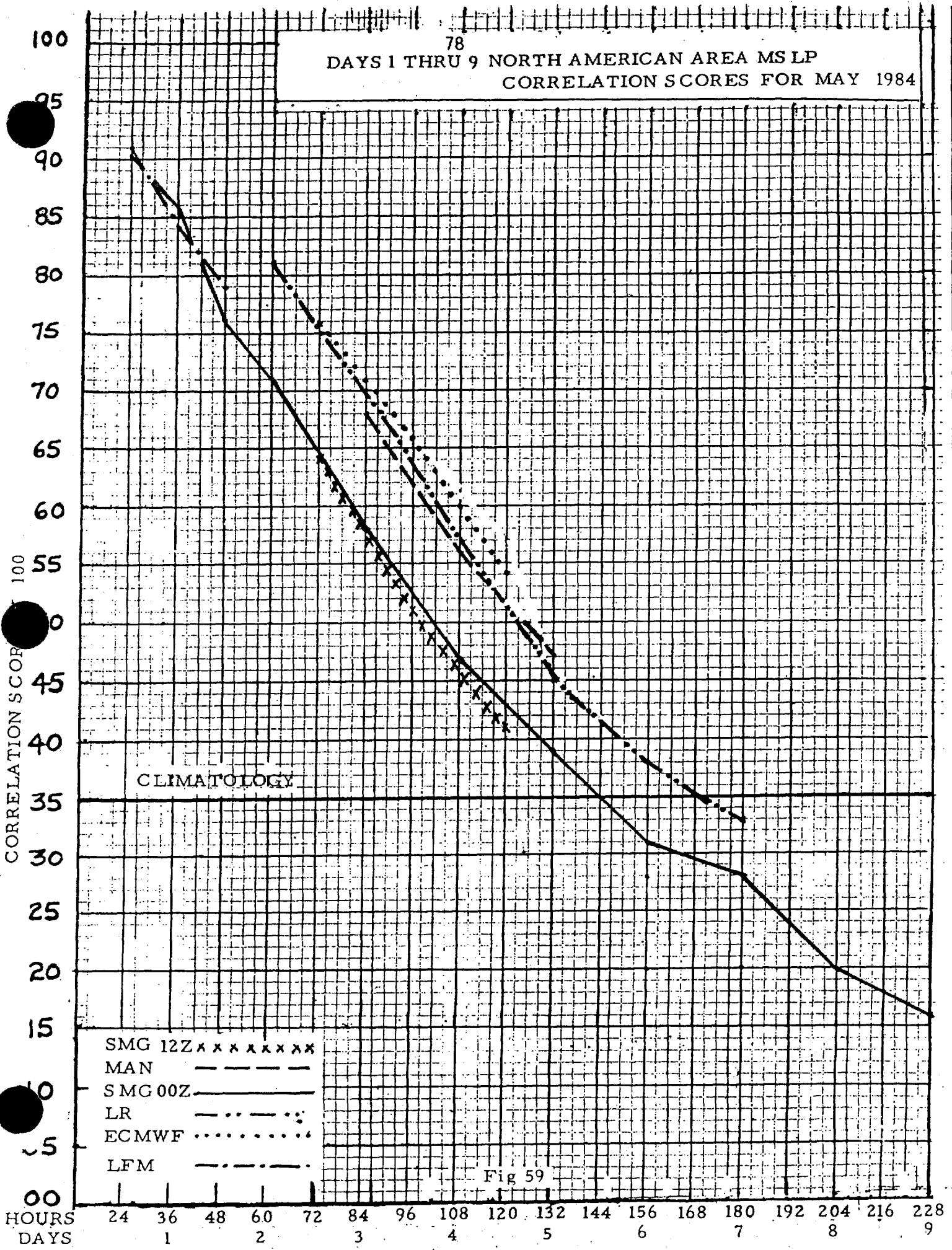
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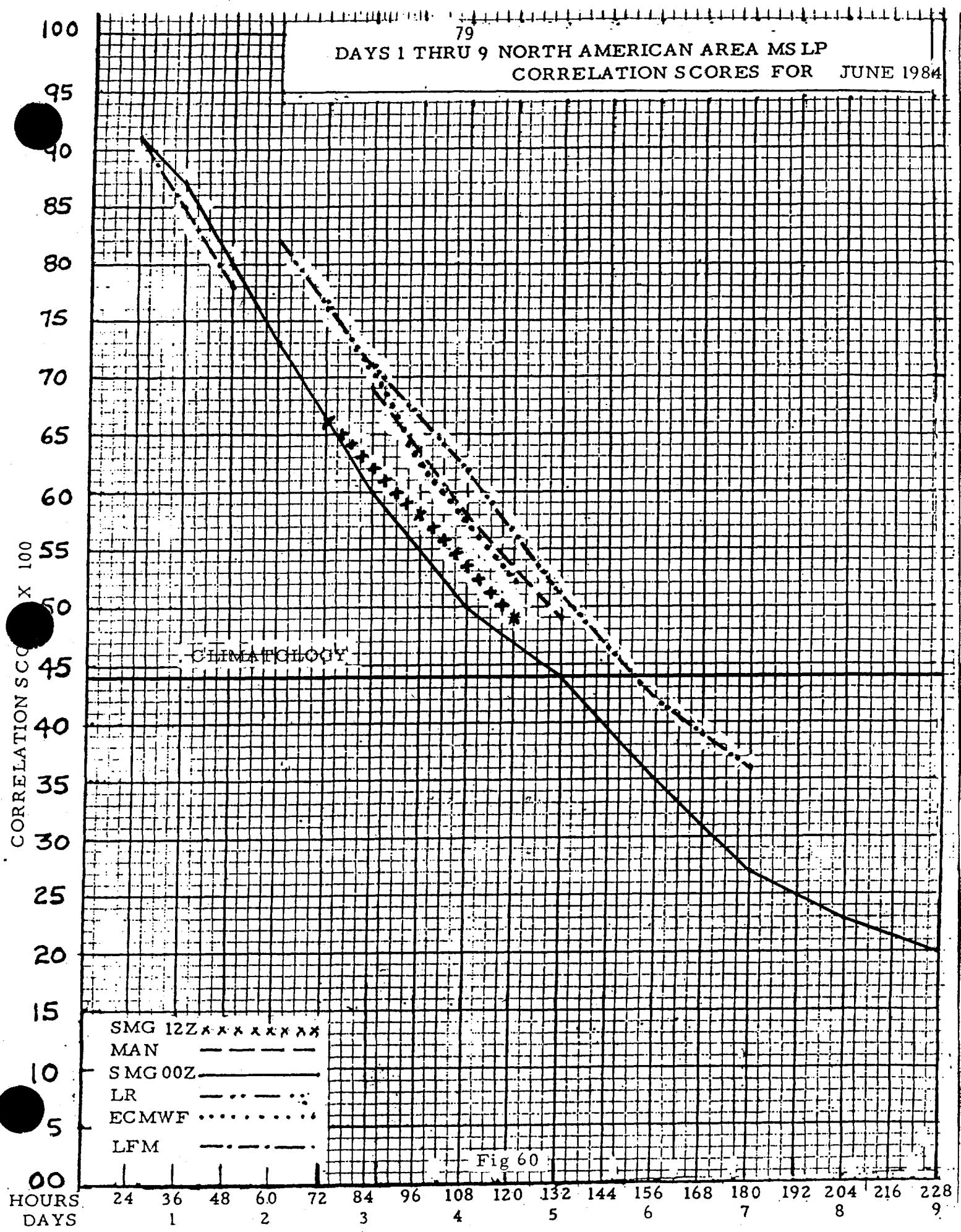
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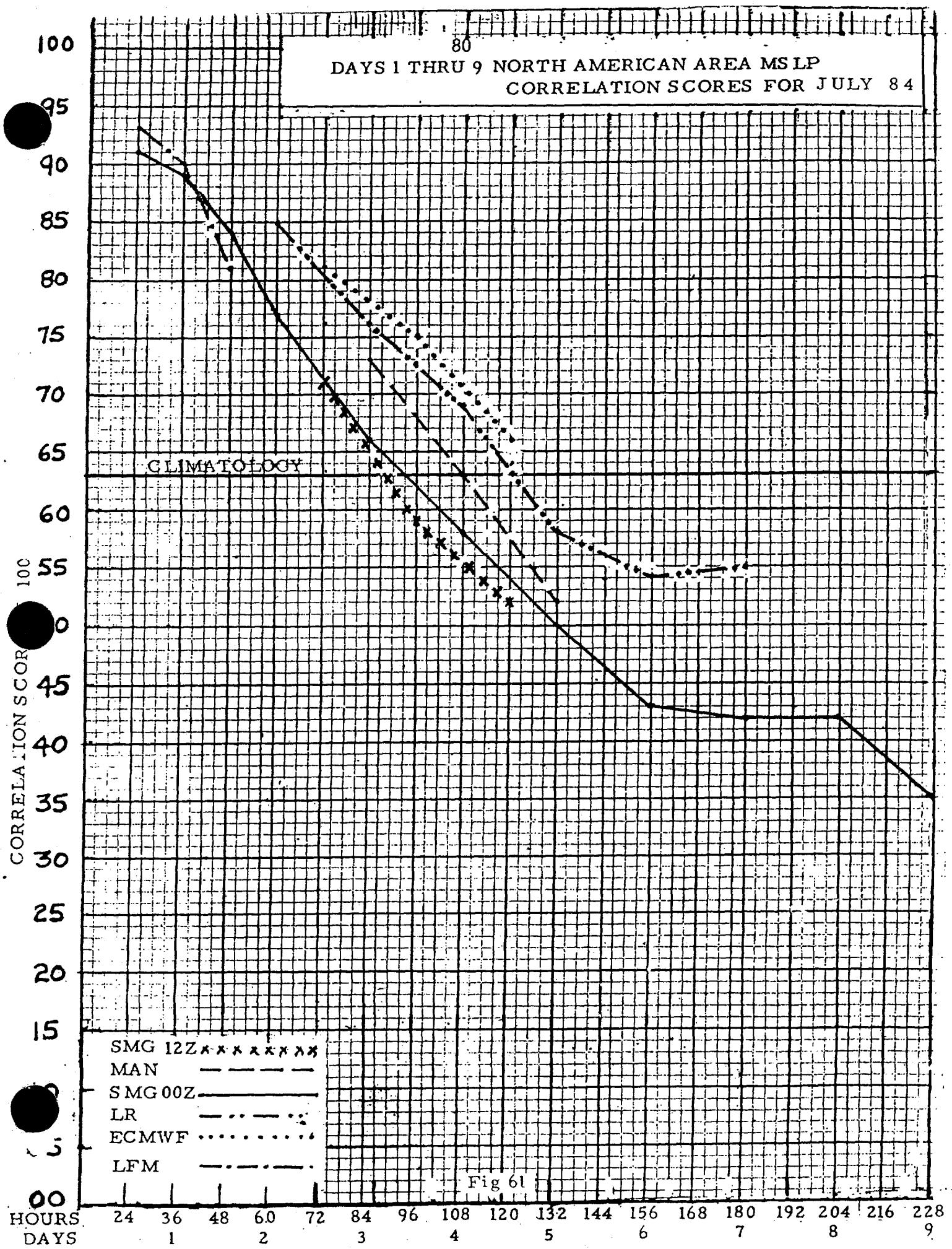
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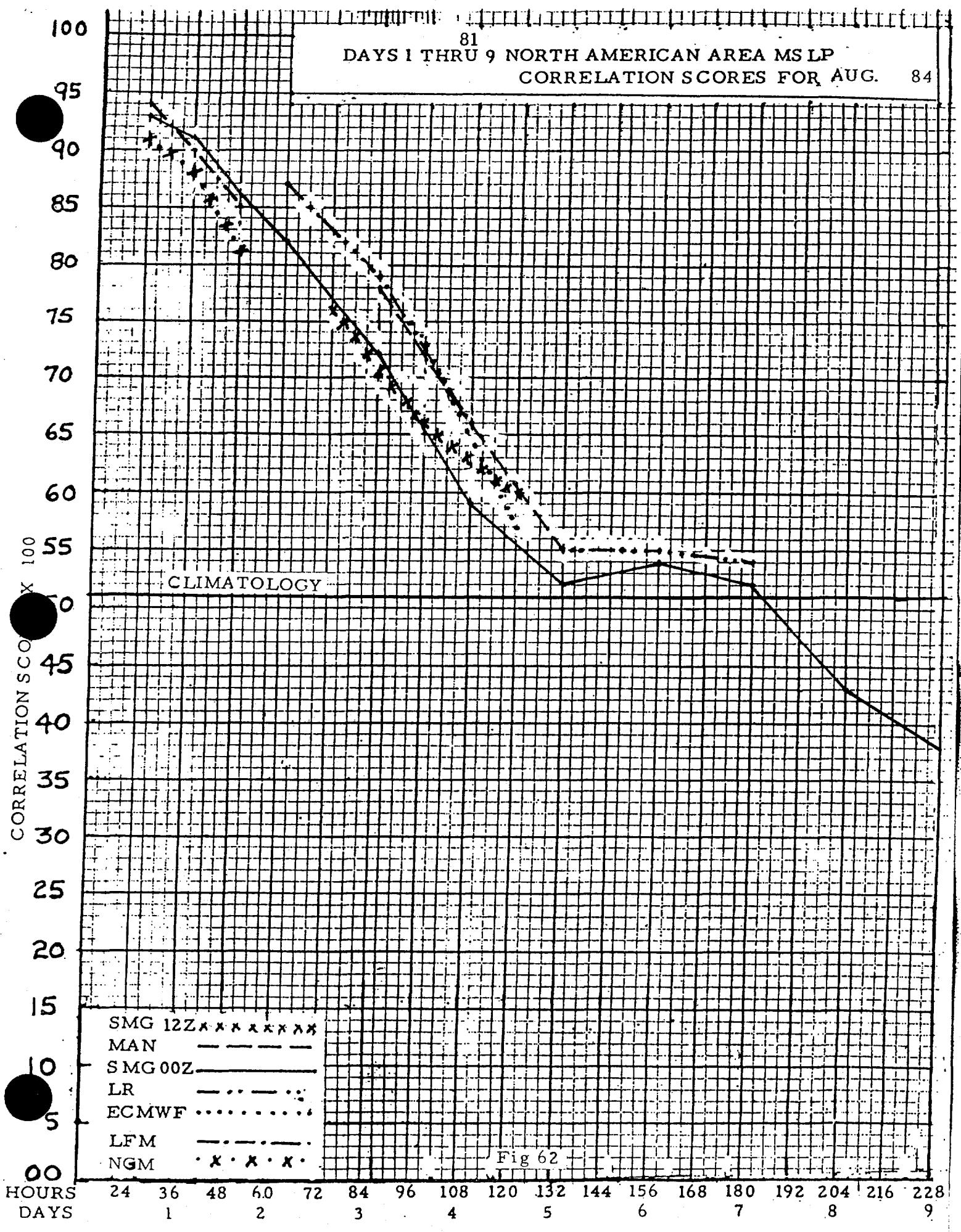
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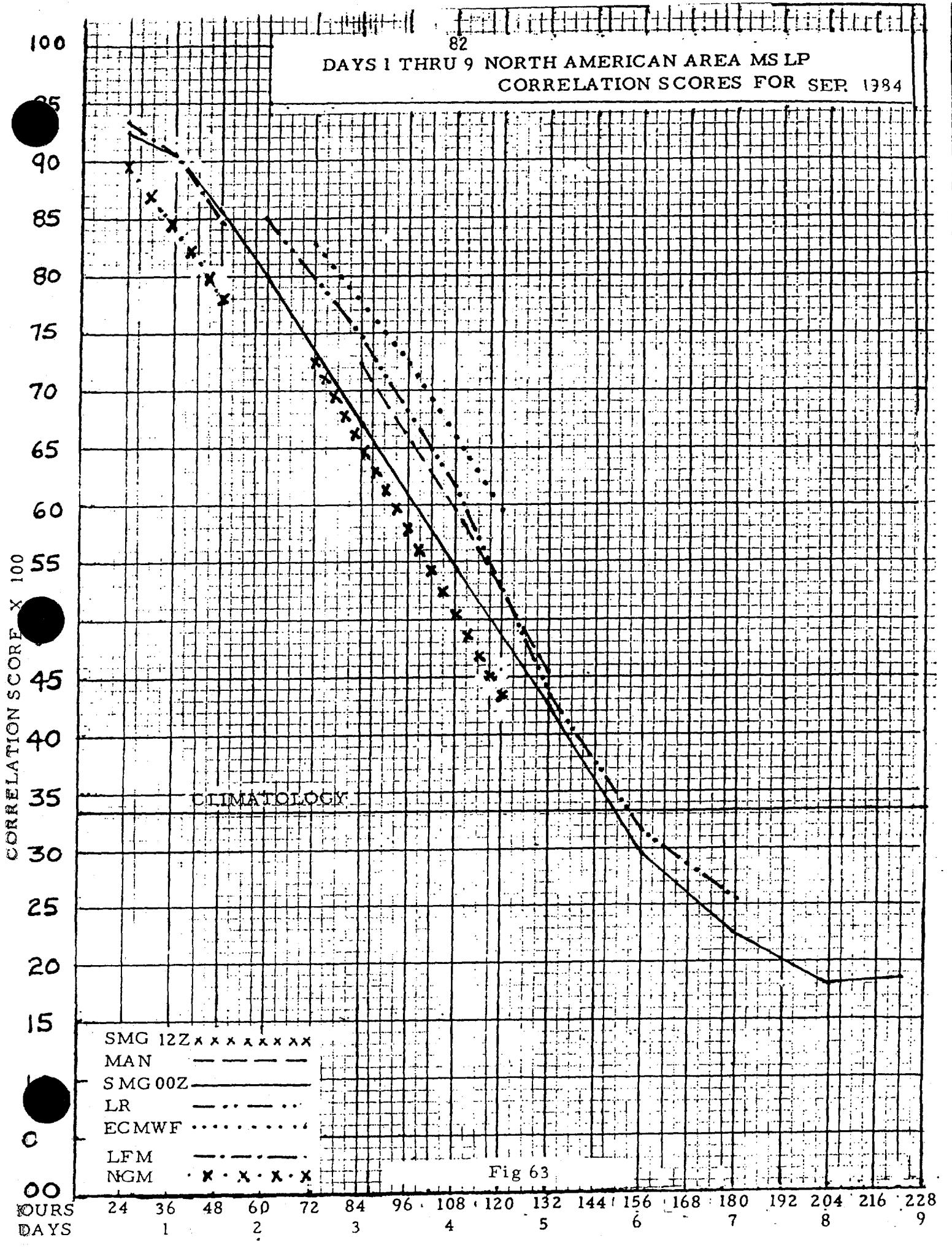
7

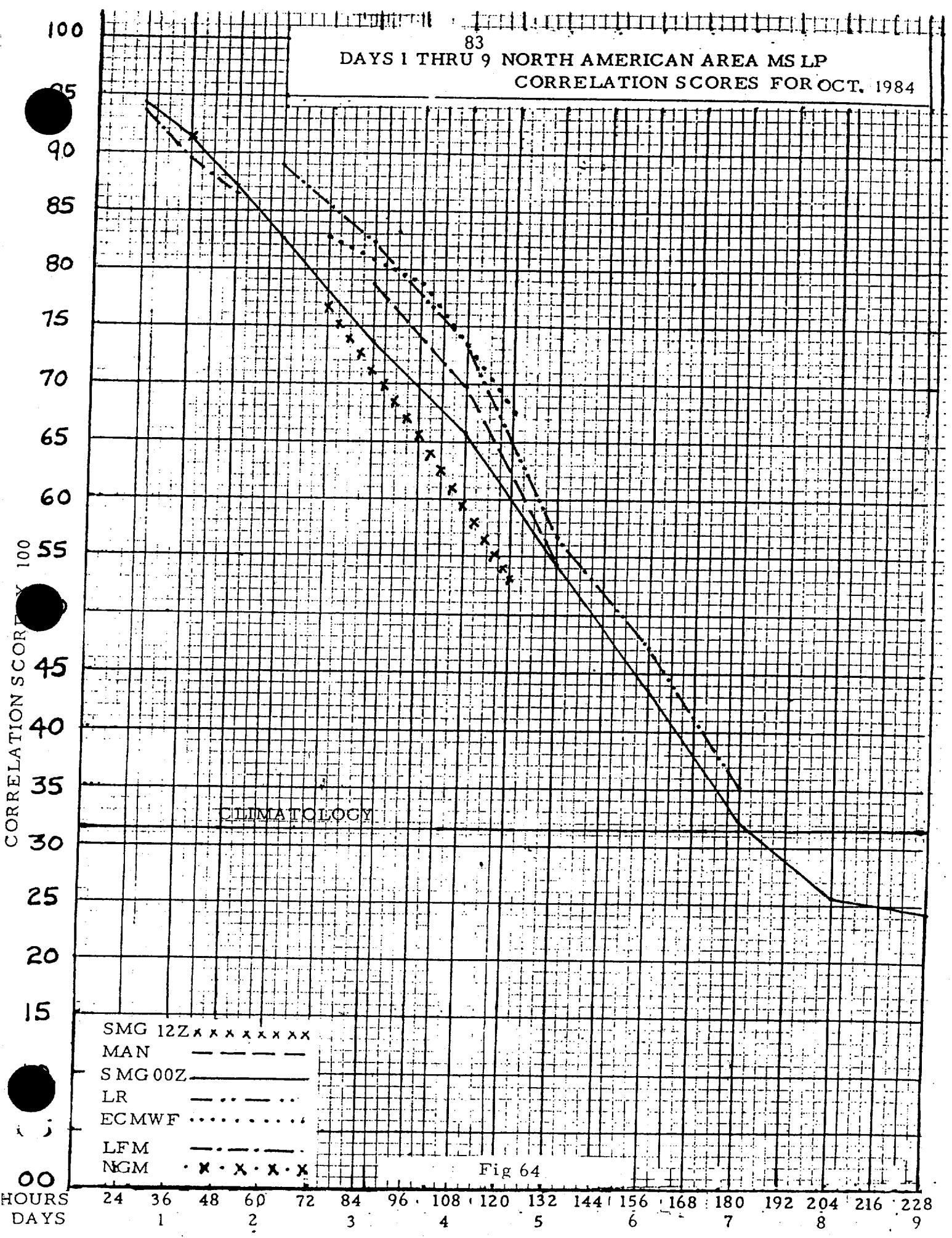




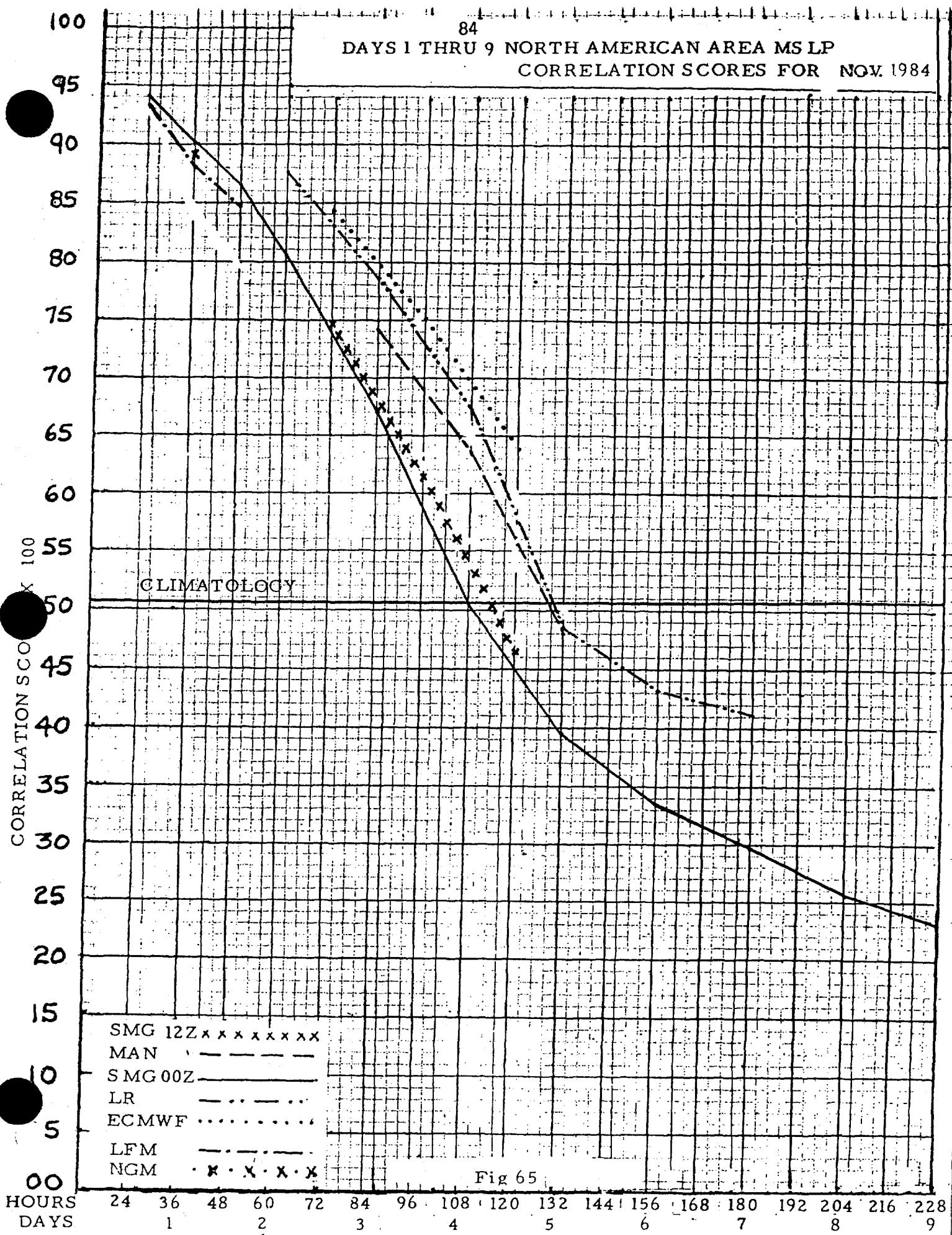




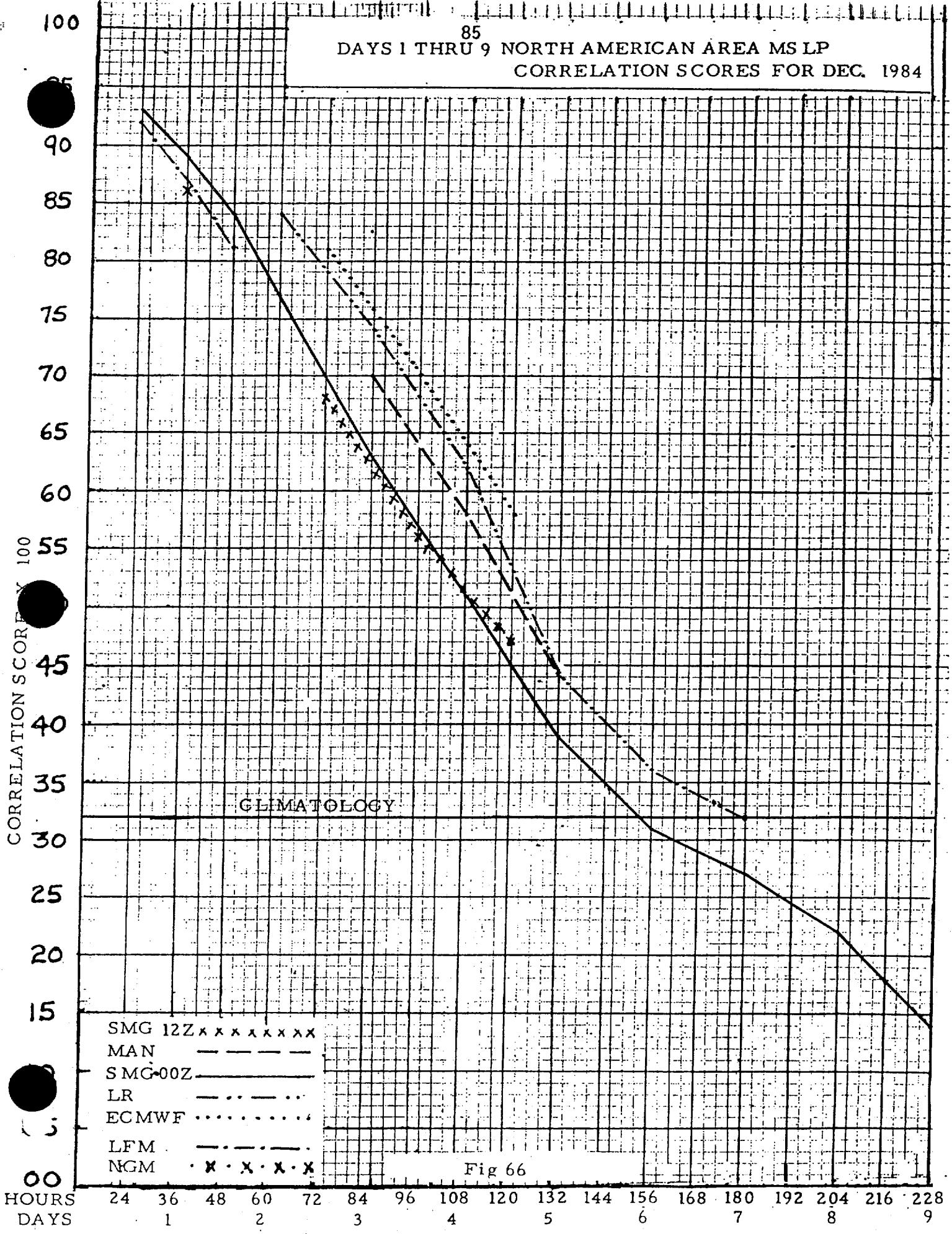




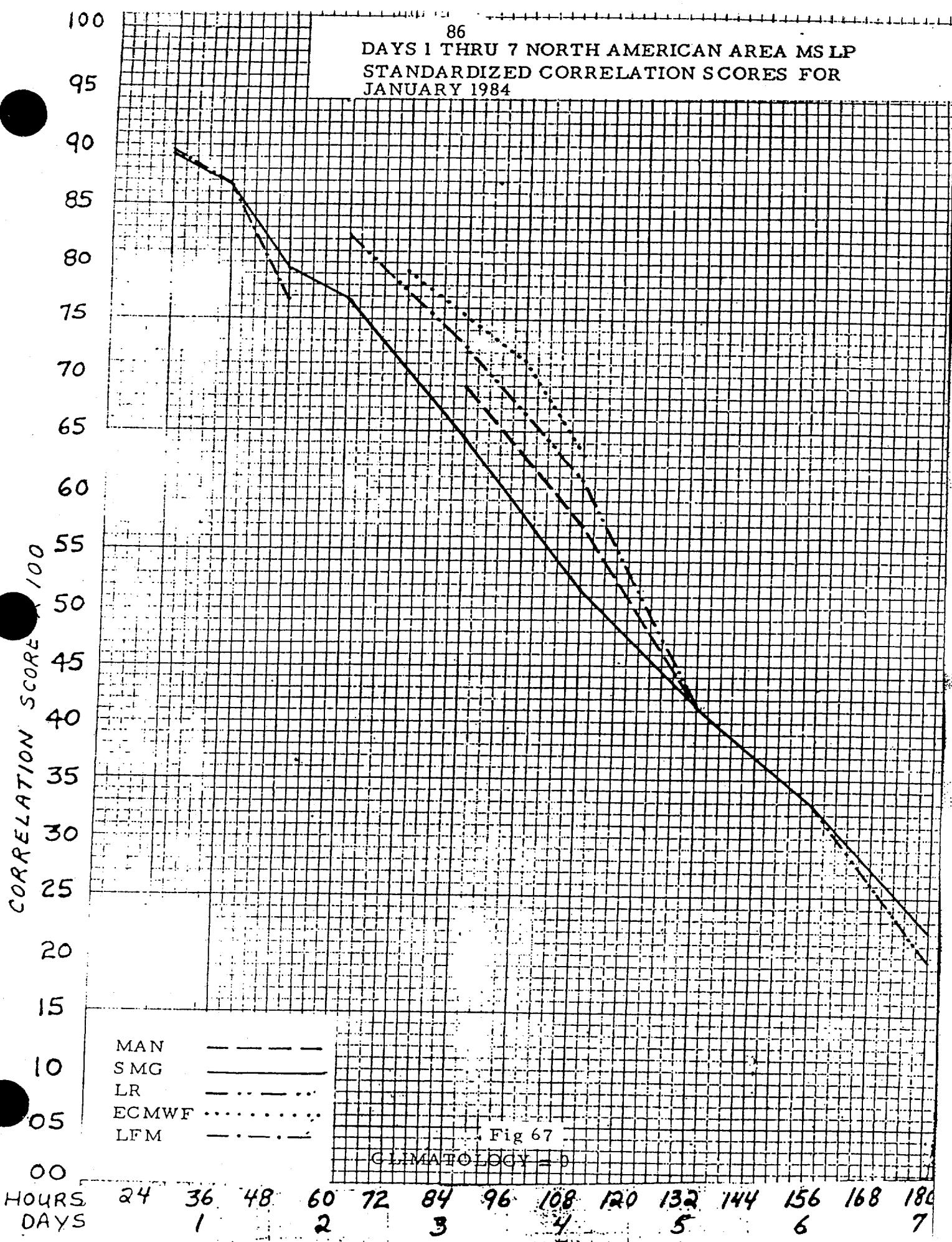
84  
DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
CORRELATION SCORES FOR NOV. 1984



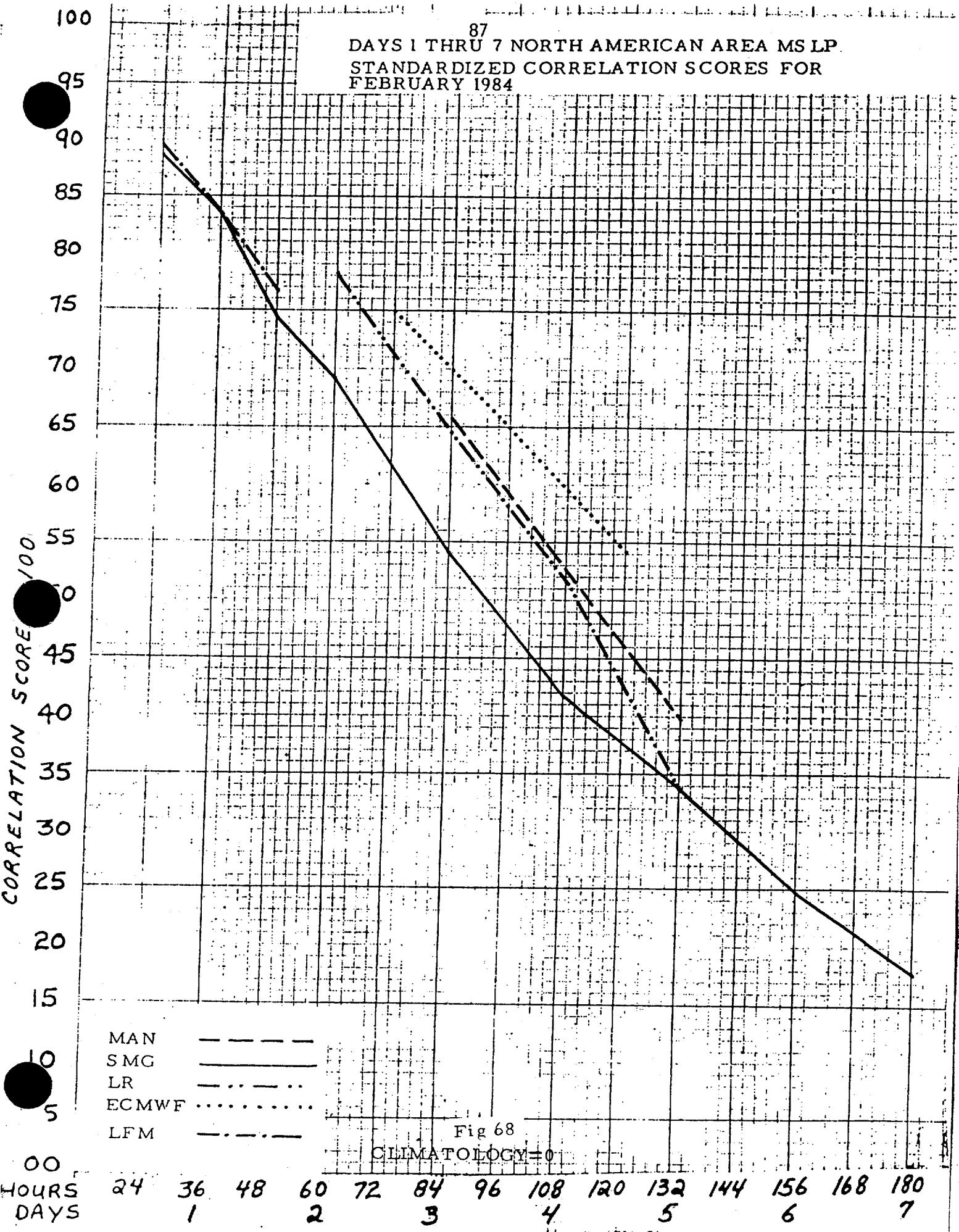
85  
DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
CORRELATION SCORES FOR DEC. 1984



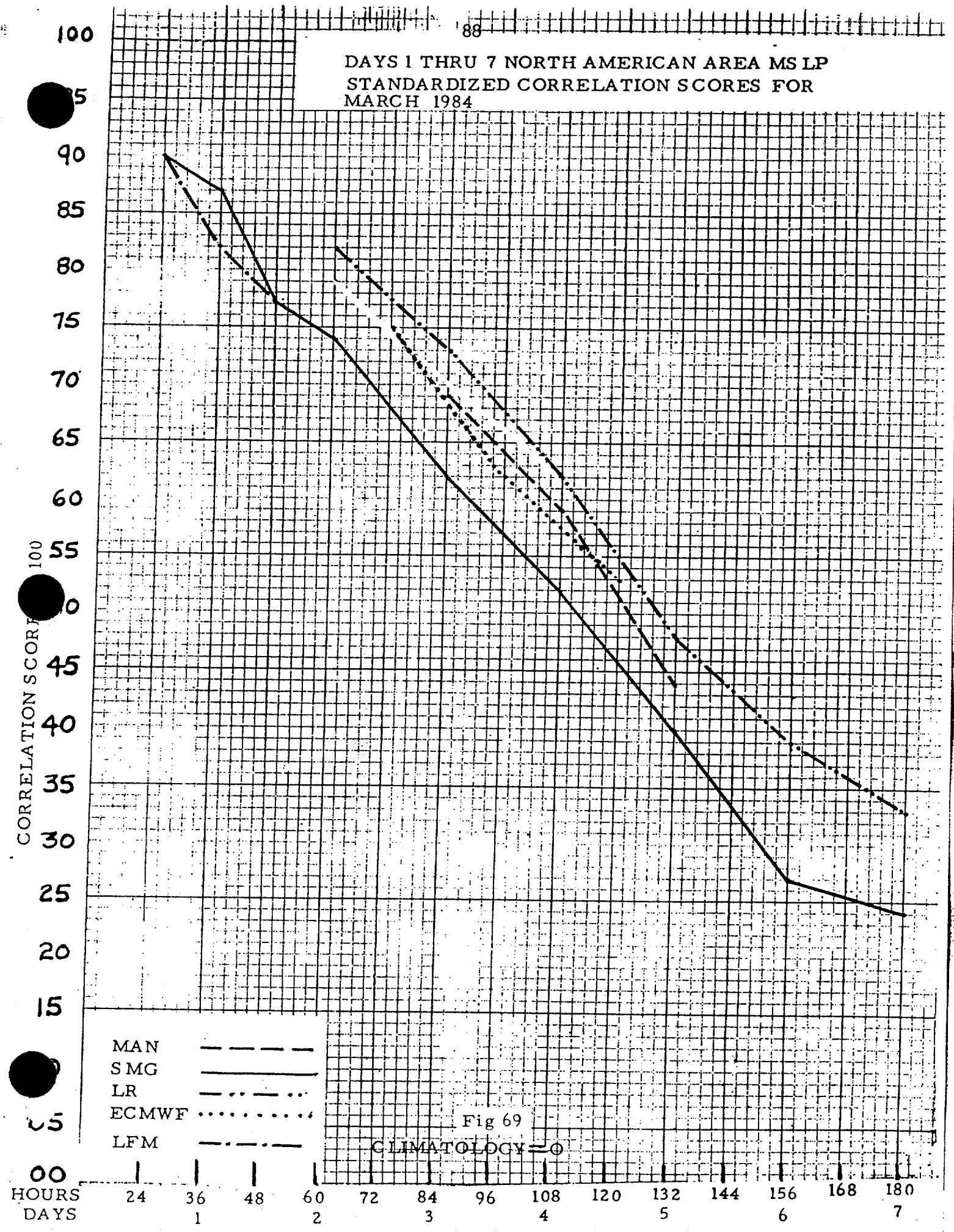
86  
DAYS 1 THRU 7 NORTH AMERICAN AREA MS LP  
STANDARDIZED CORRELATION SCORES FOR  
JANUARY 1984



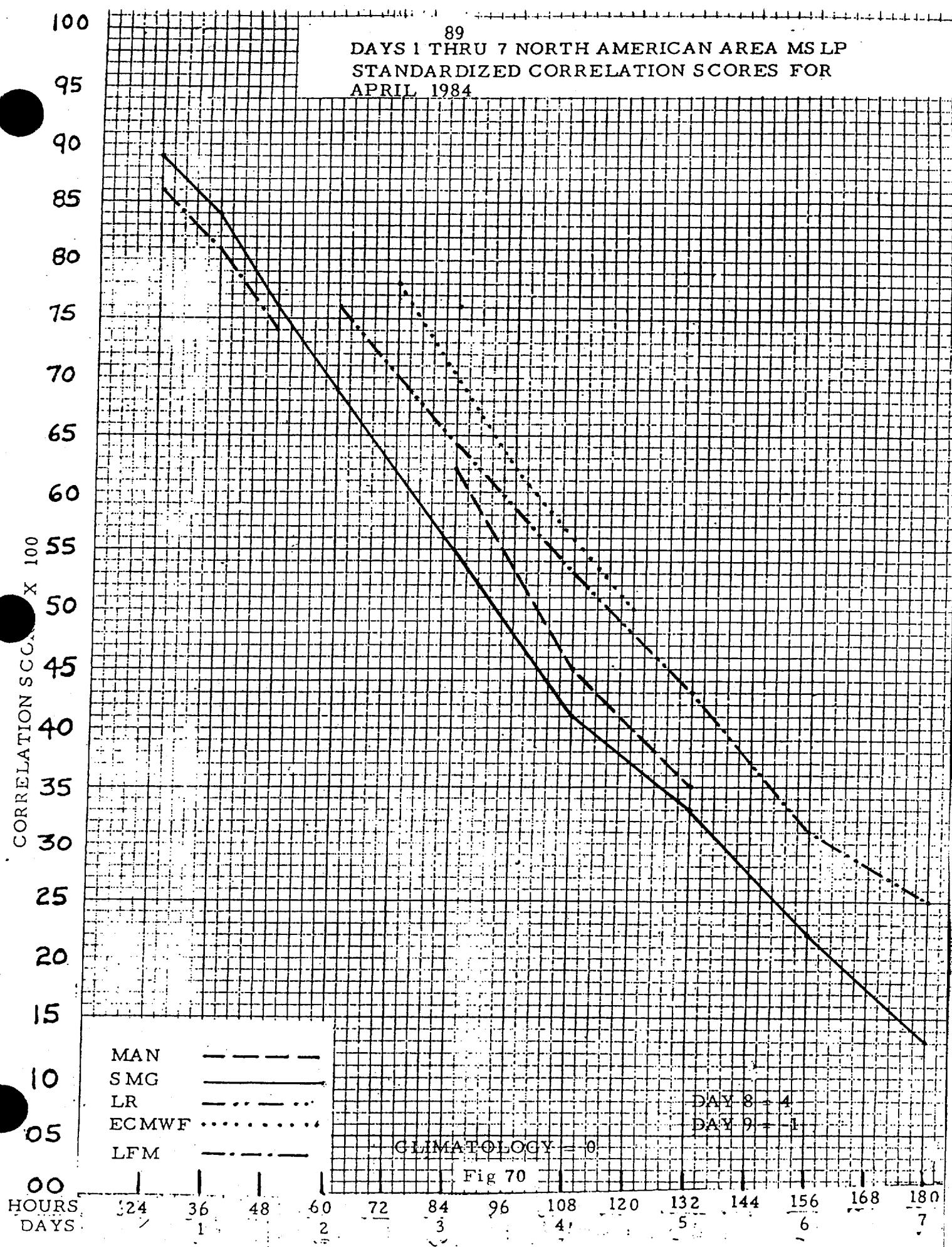
87  
 DAYS 1 THRU 7 NORTH AMERICAN AREA MS LP  
 STANDARDIZED CORRELATION SCORES FOR  
 FEBRUARY 1984



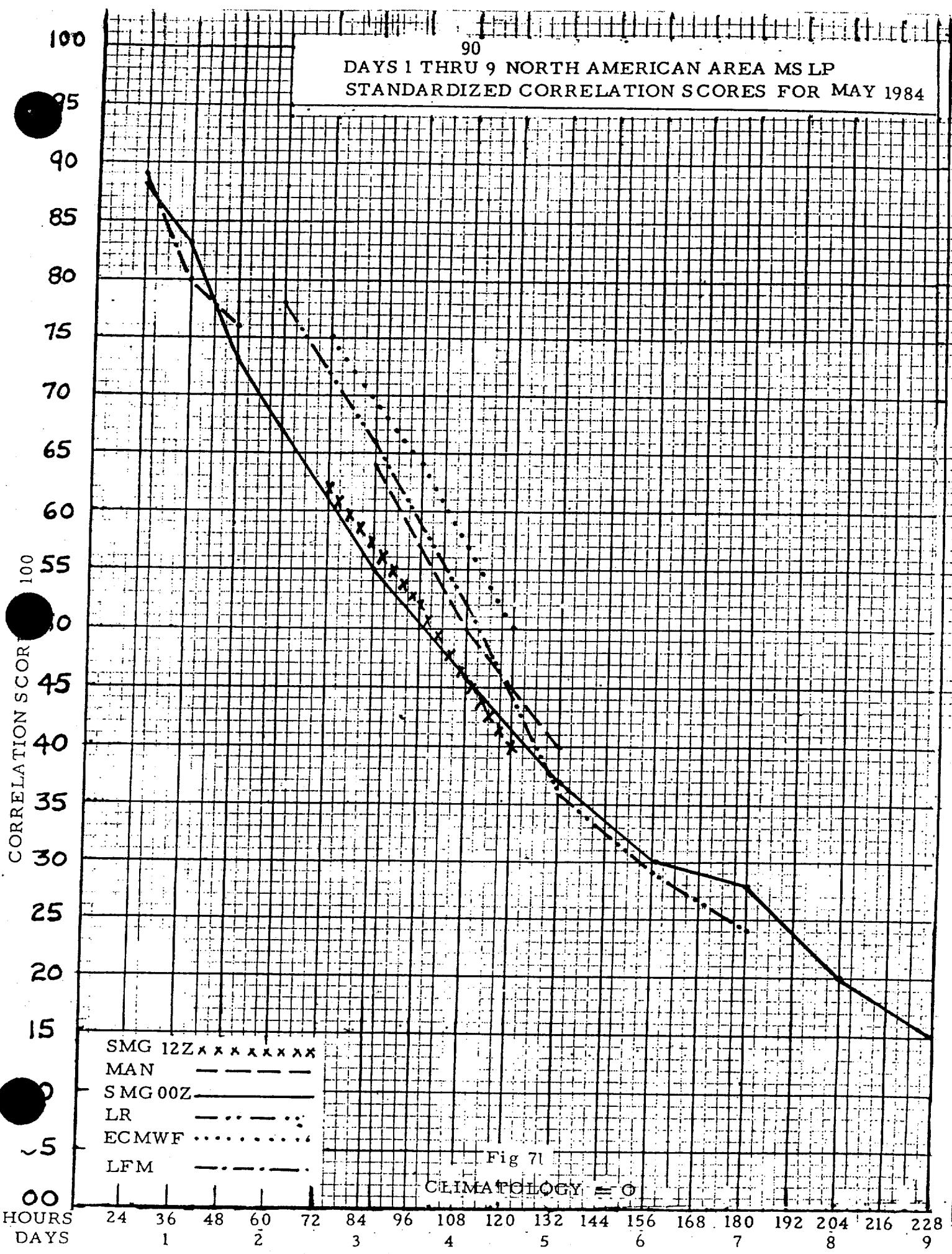
DAYS 1 THRU 7 NORTH AMERICAN AREA MS LP  
STANDARDIZED CORRELATION SCORES FOR  
MARCH 1984



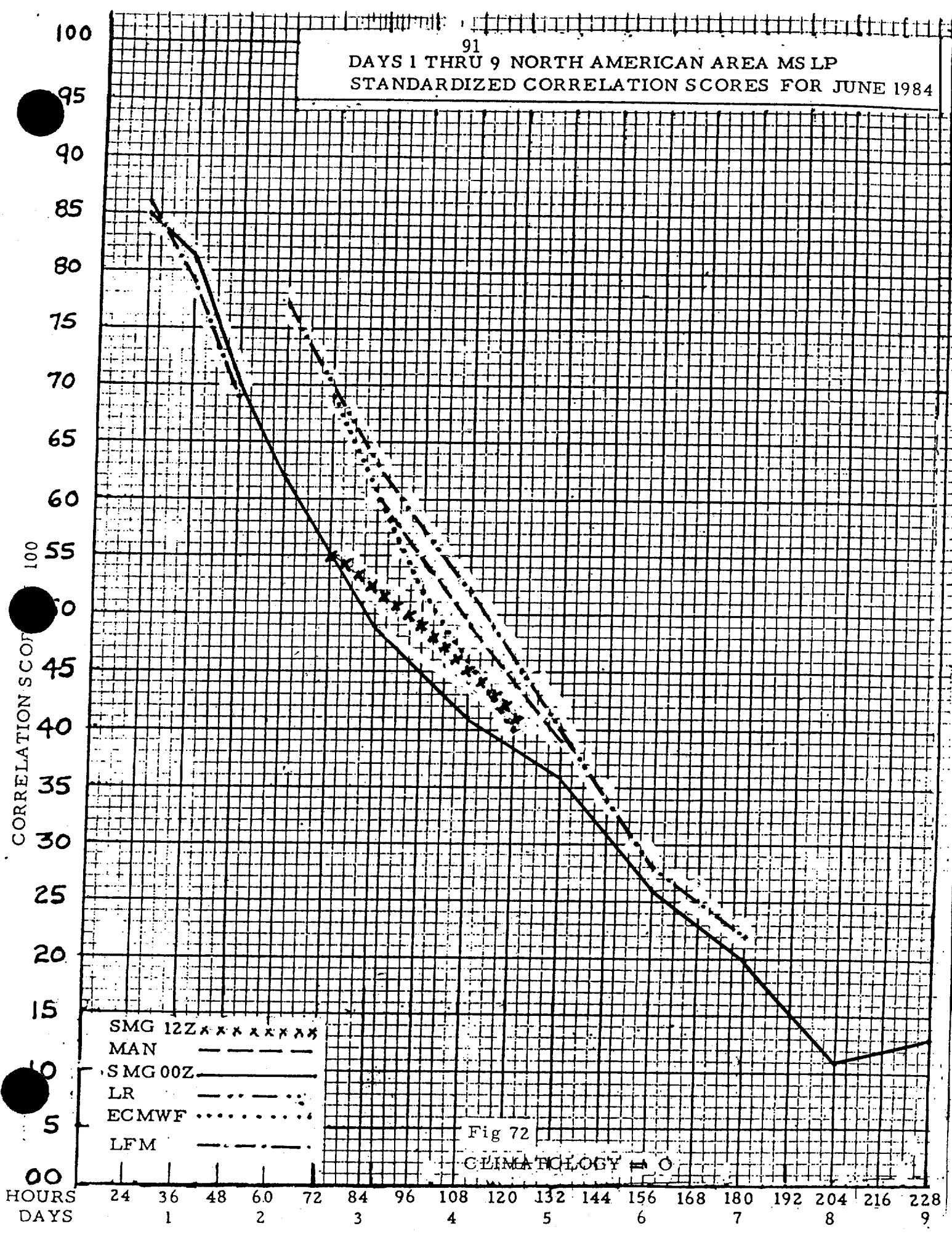
89  
DAYS 1 THRU 7 NORTH AMERICAN AREA MS LP  
STANDARDIZED CORRELATION SCORES FOR  
APRIL 1984



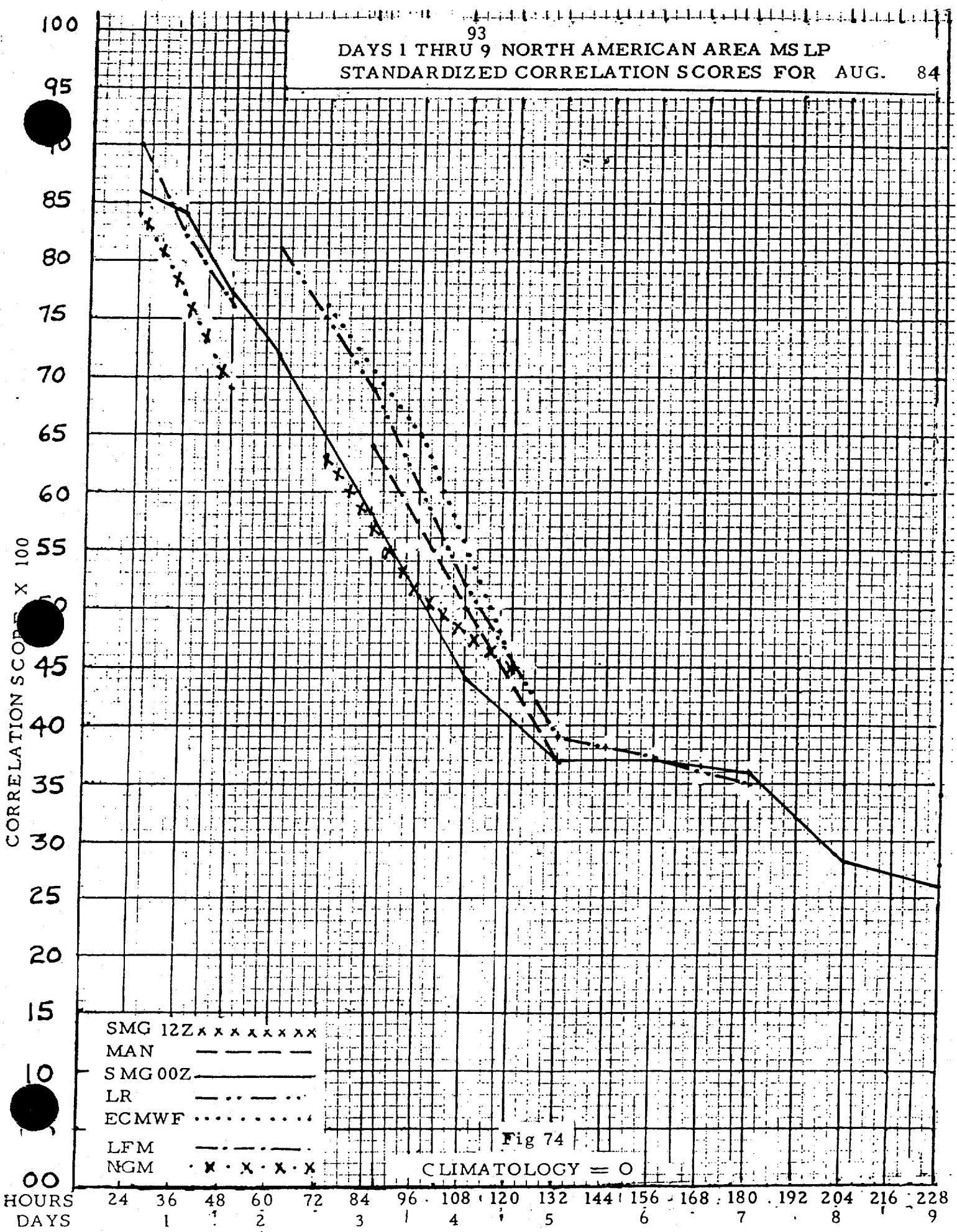
90  
 DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
 STANDARDIZED CORRELATION SCORES FOR MAY 1984



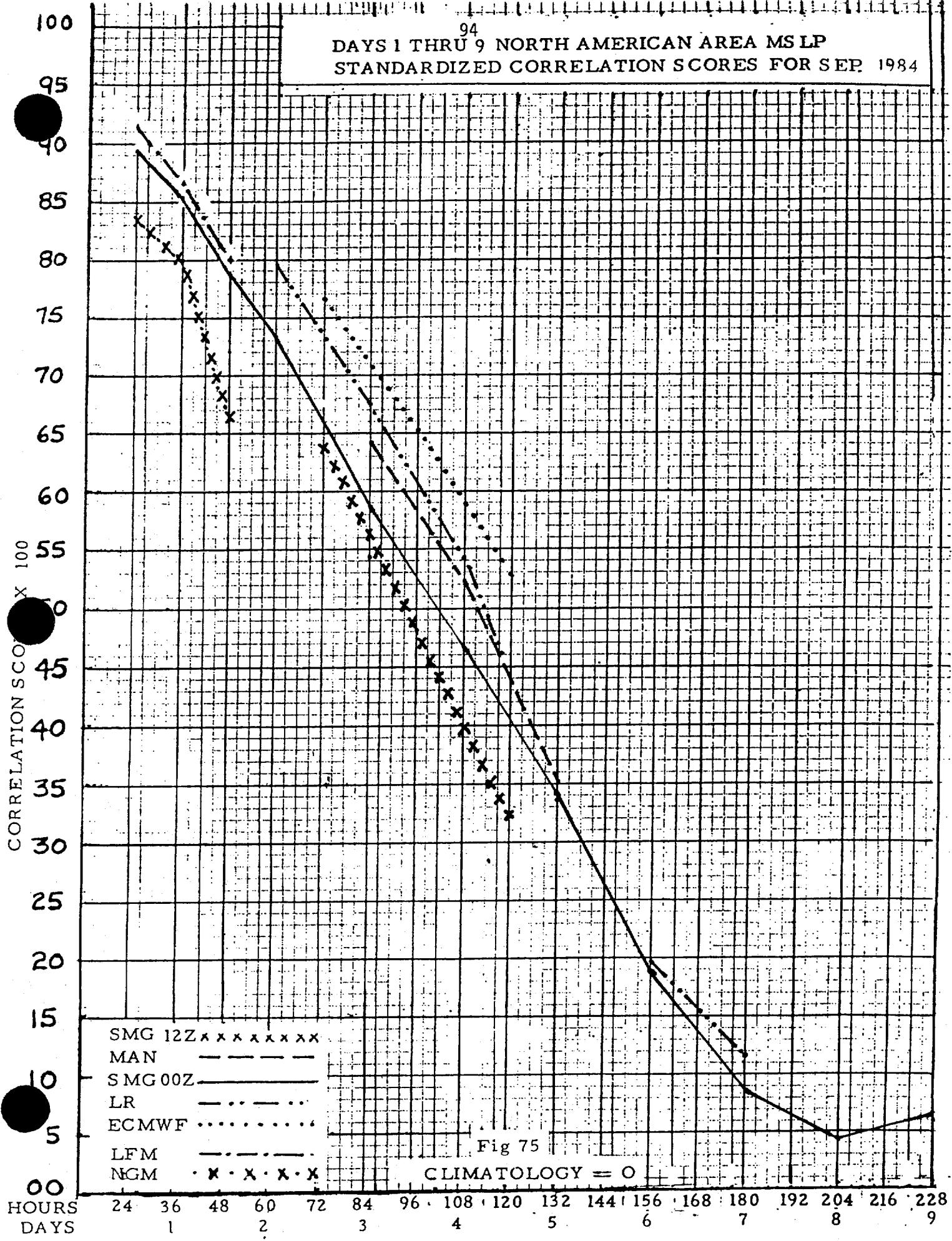
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DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
STANDARDIZED CORRELATION SCORES FOR JUNE 1984



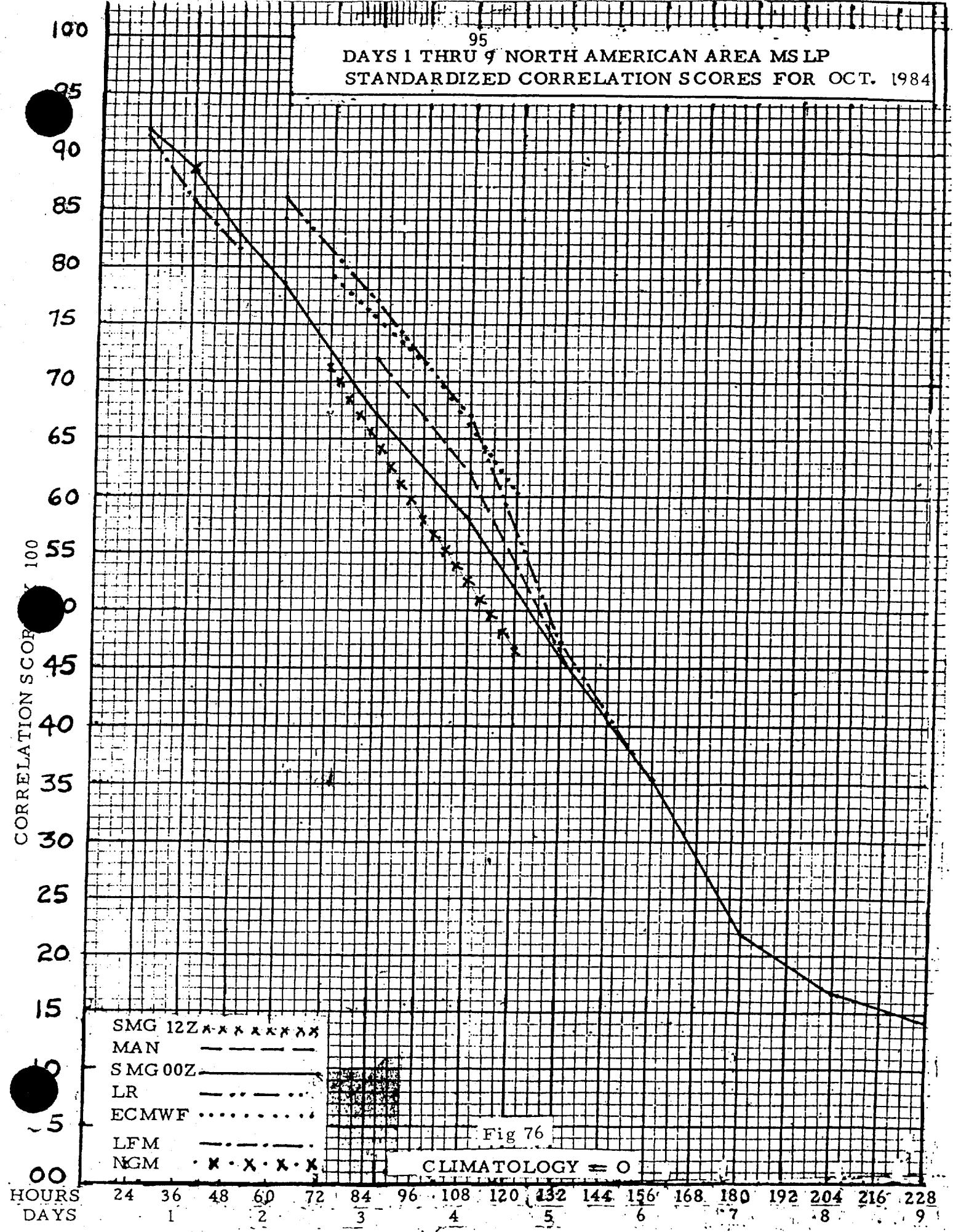
93  
DAYS 1 THRU 9 NORTH AMERICAN AREA MSLP  
STANDARDIZED CORRELATION SCORES FOR AUG. 84



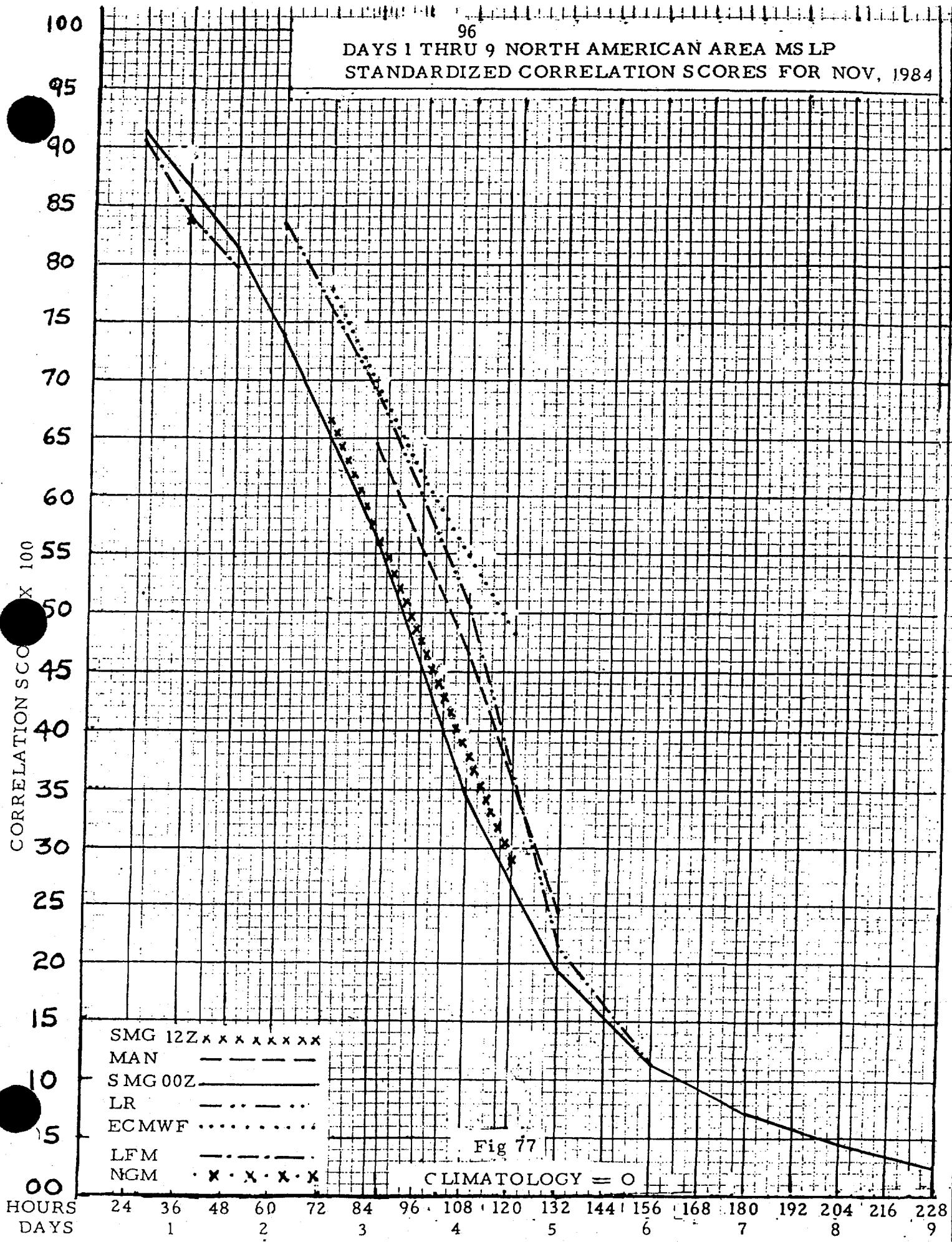
94  
DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
STANDARDIZED CORRELATION SCORES FOR SEP. 1984



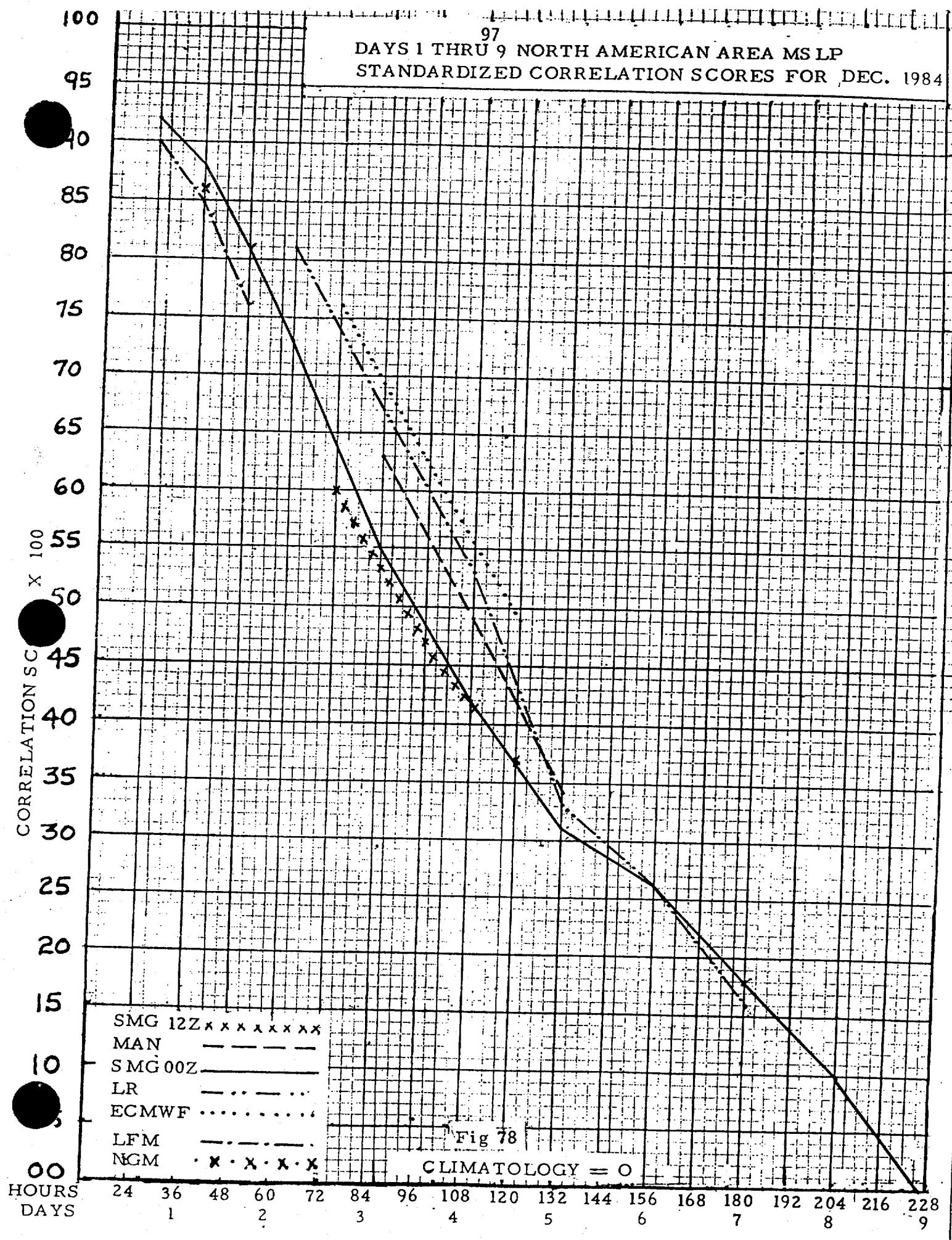
95  
DAYS 1 THRU 9 NORTH AMERICAN AREA MSLP  
STANDARDIZED CORRELATION SCORES FOR OCT. 1984



96  
DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
STANDARDIZED CORRELATION SCORES FOR NOV, 1984

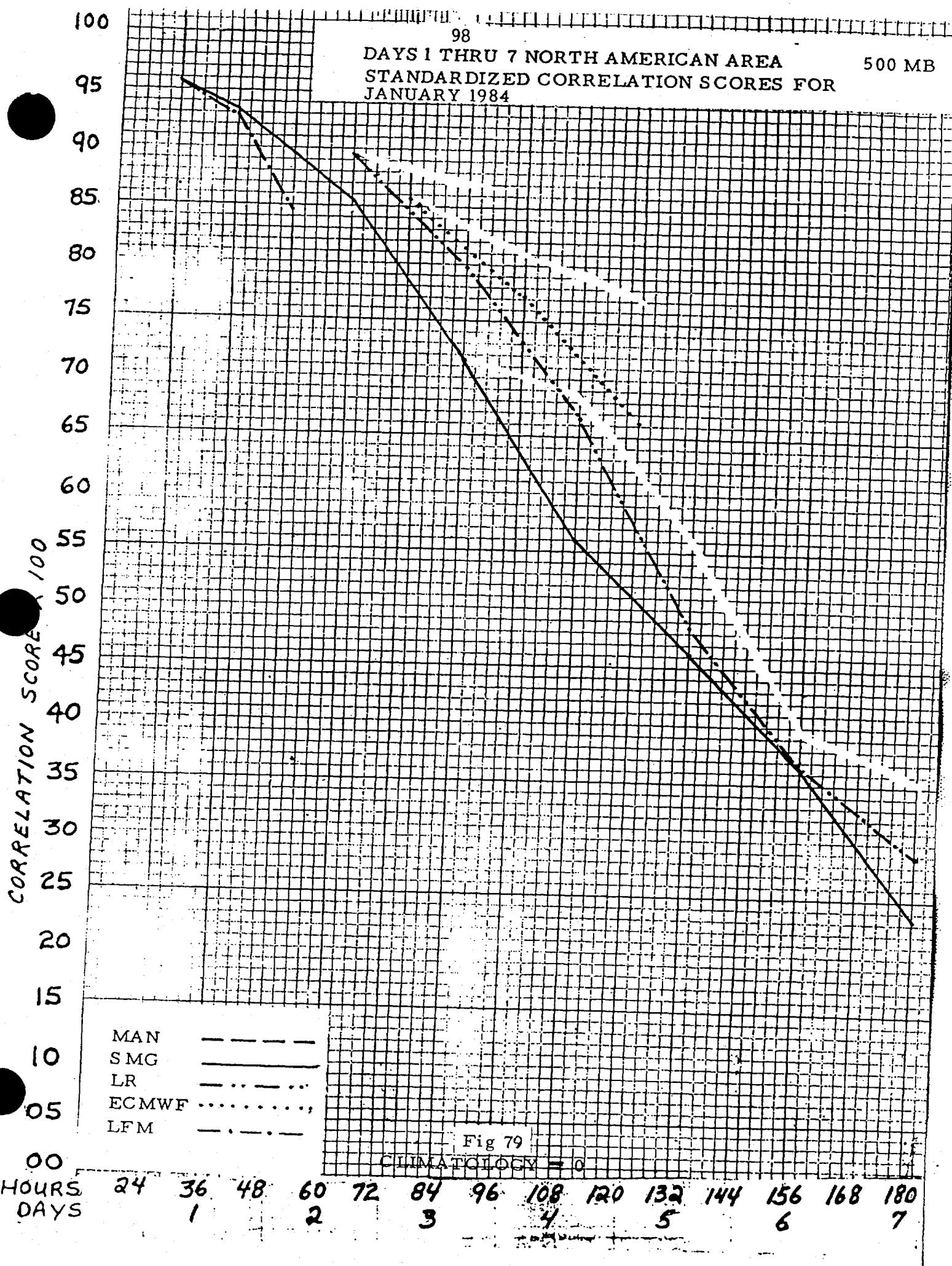


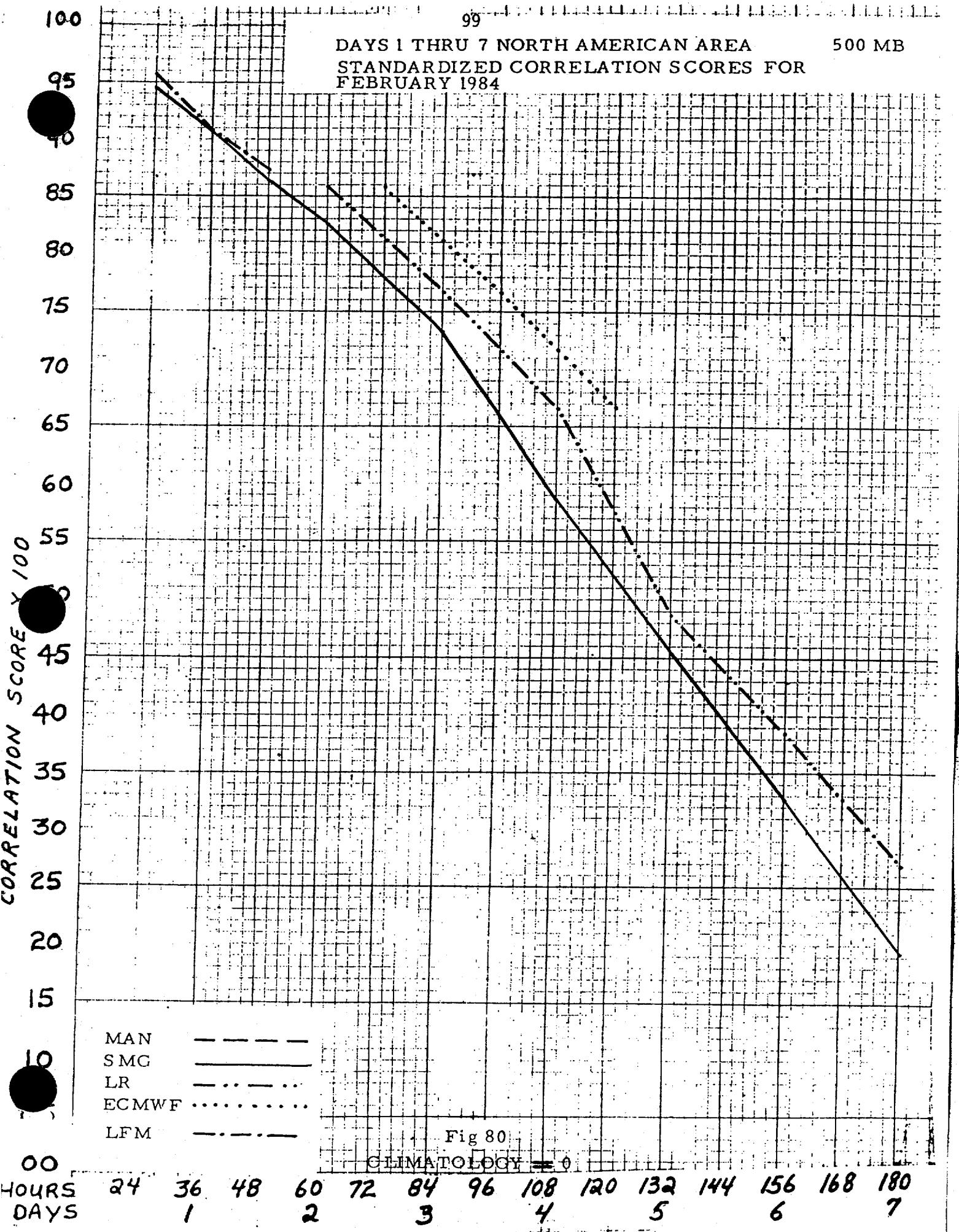
97  
 DAYS 1 THRU 9 NORTH AMERICAN AREA MS LP  
 STANDARDIZED CORRELATION SCORES FOR DEC. 1984

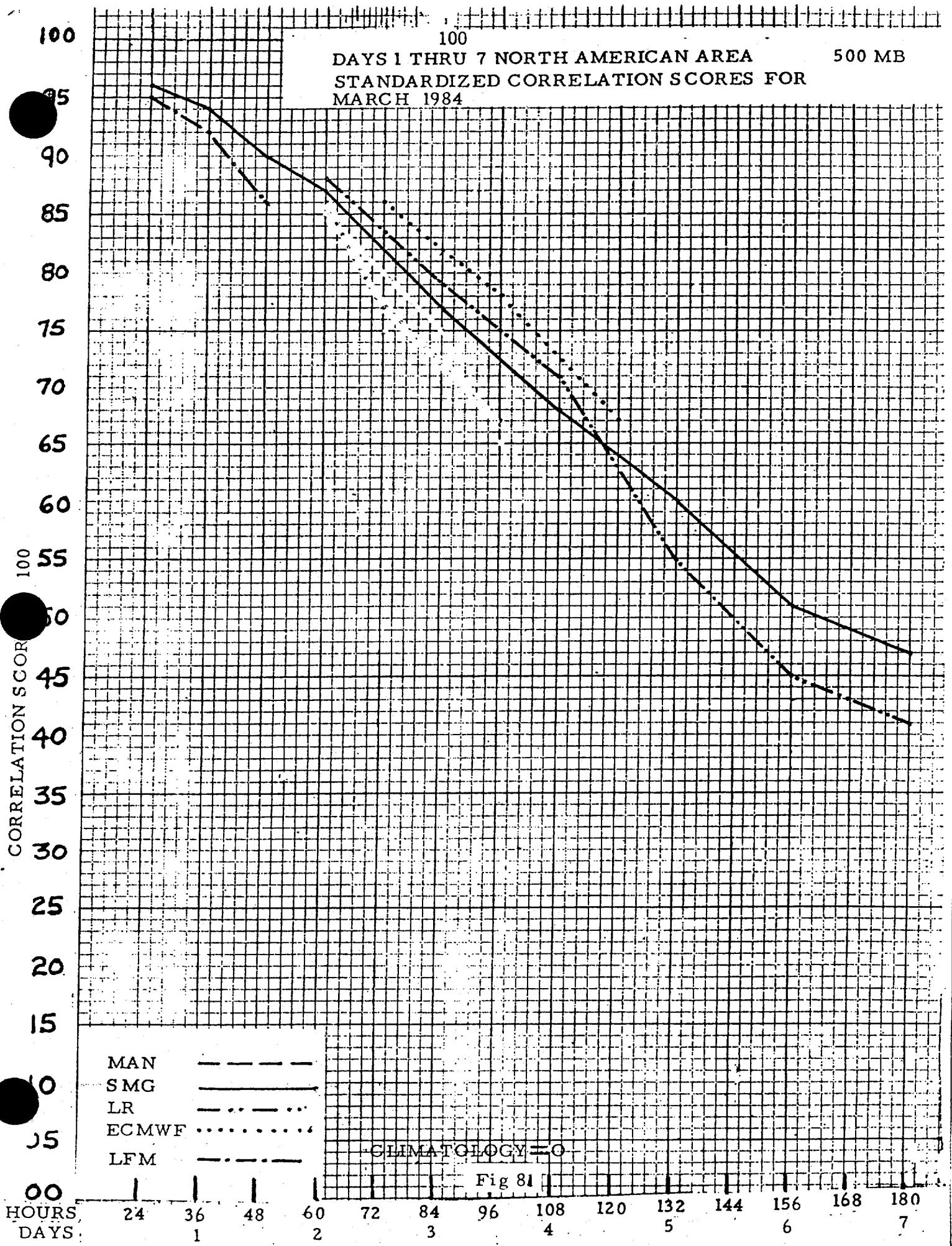


98  
 DAYS 1 THRU 7 NORTH AMERICAN AREA  
 STANDARDIZED CORRELATION SCORES FOR  
 JANUARY 1984

500 MB

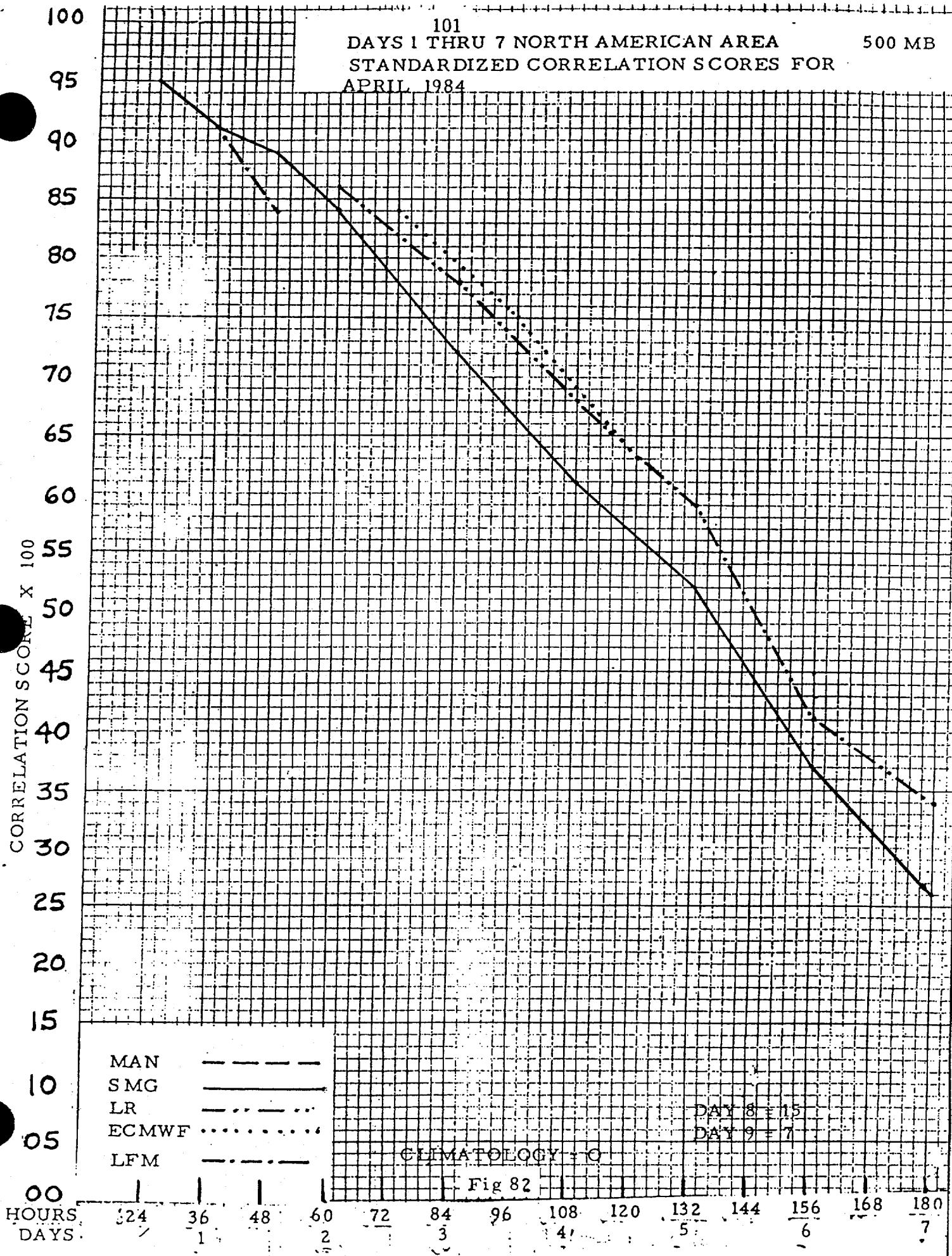


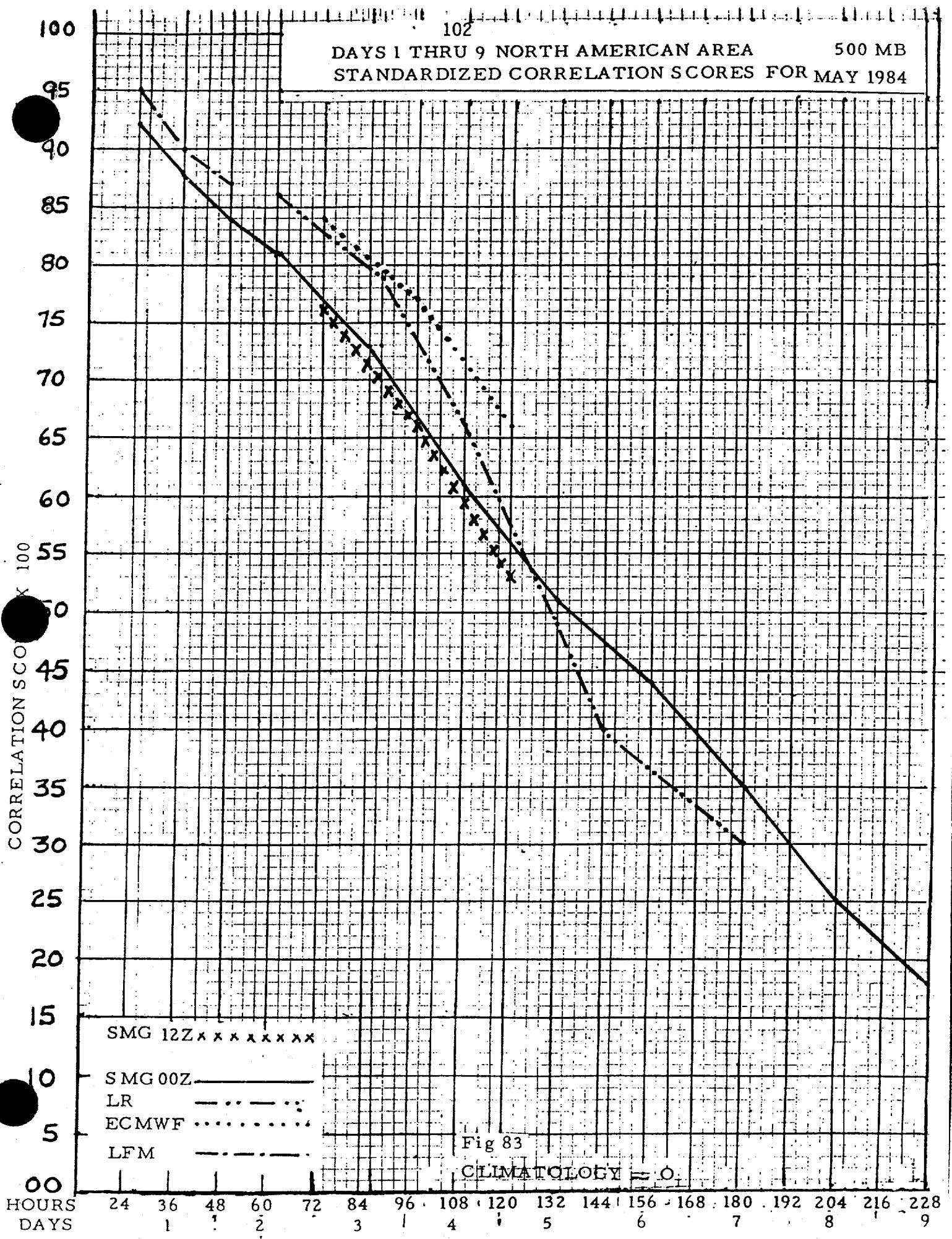




101  
DAYS 1 THRU 7 NORTH AMERICAN AREA  
STANDARDIZED CORRELATION SCORES FOR  
APRIL, 1984

500 MB



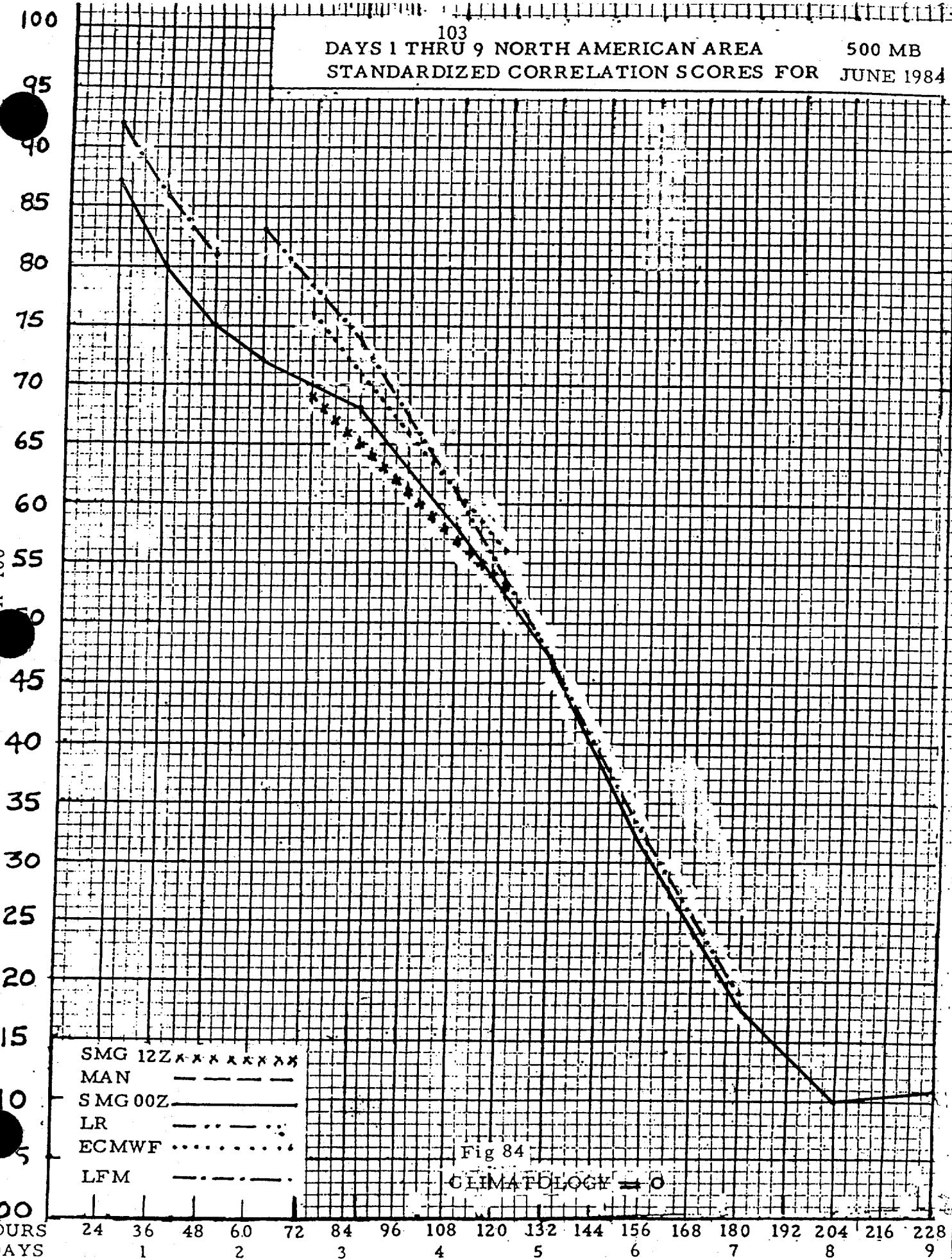


103  
DAYS 1 THRU 9 NORTH AMERICAN AREA  
STANDARDIZED CORRELATION SCORES FOR JUNE 1984

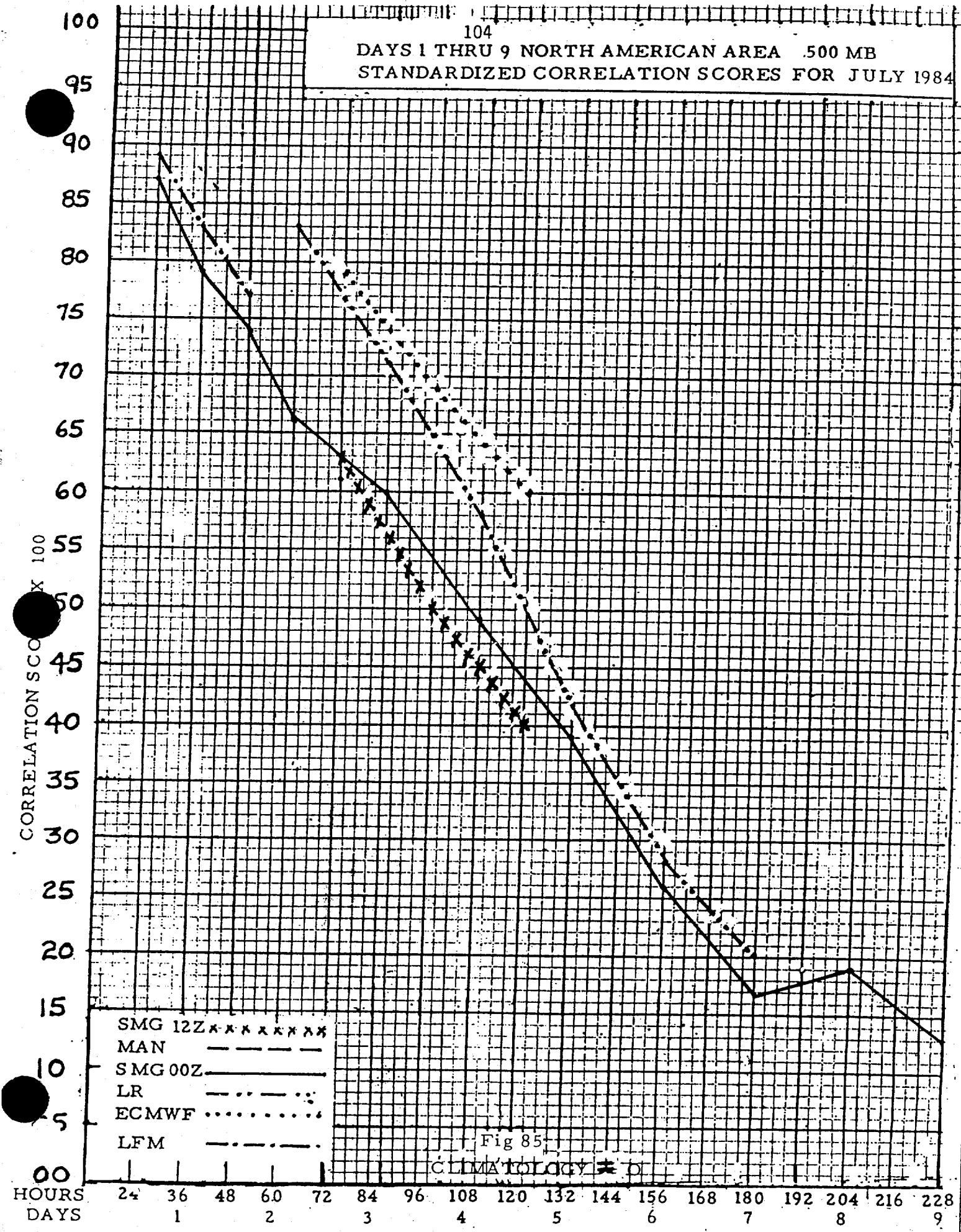
500 MB

CORRELATION SCORE

HOURS  
DAYS



104  
 DAYS 1 THRU 9 NORTH AMERICAN AREA .500 MB  
 STANDARDIZED CORRELATION SCORES FOR JULY 1984



105  
DAYS 1 THRU 9 NORTH AMERICAN AREA  
STANDARDIZED CORRELATION SCORES FOR AUG. 84

500 MB

CORRELATION SCORE X 100

HOURS  
DAYS

SMG 12Z XXXXXXXXX

MAN -----

SMG 00Z -----

LR -----

ECMWF .....

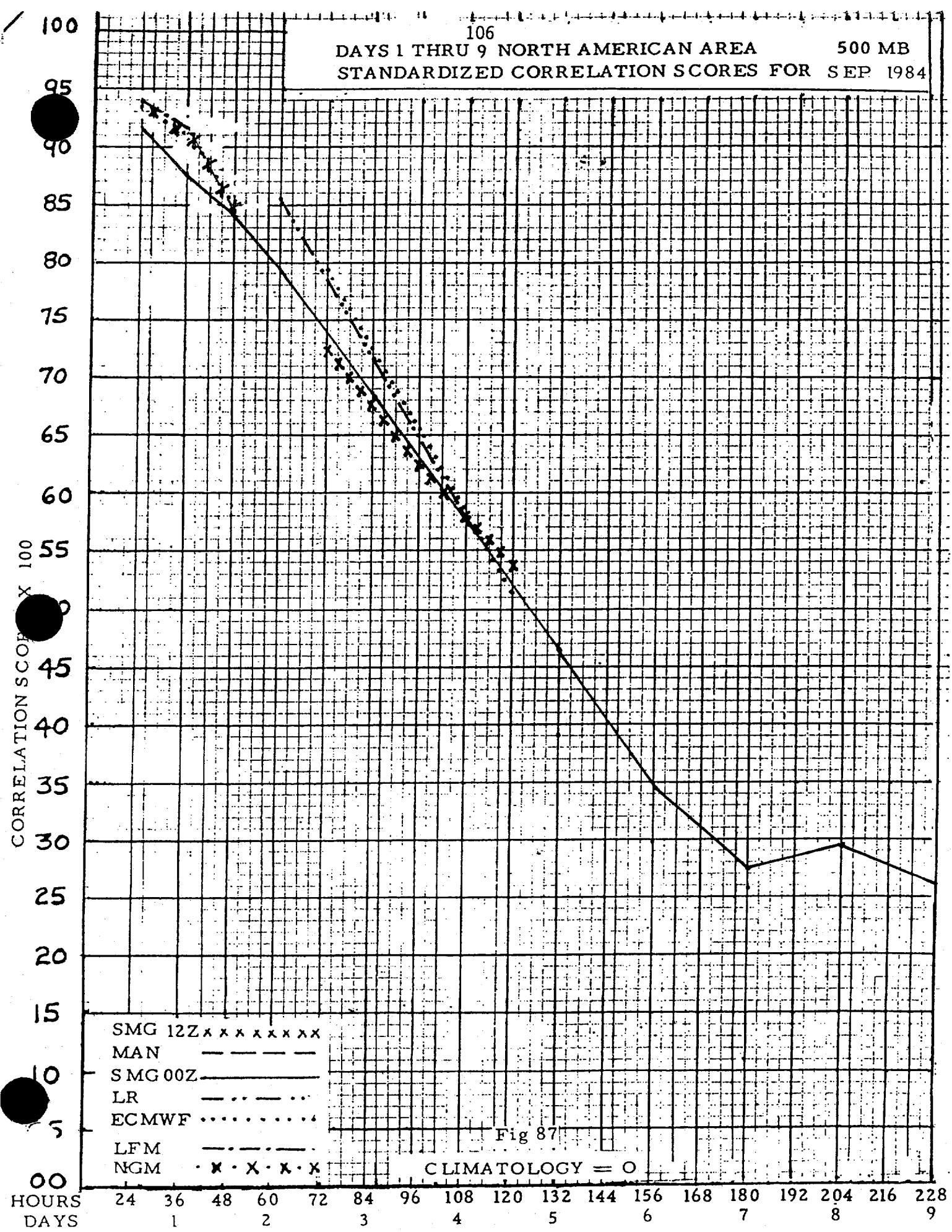
LFM -----

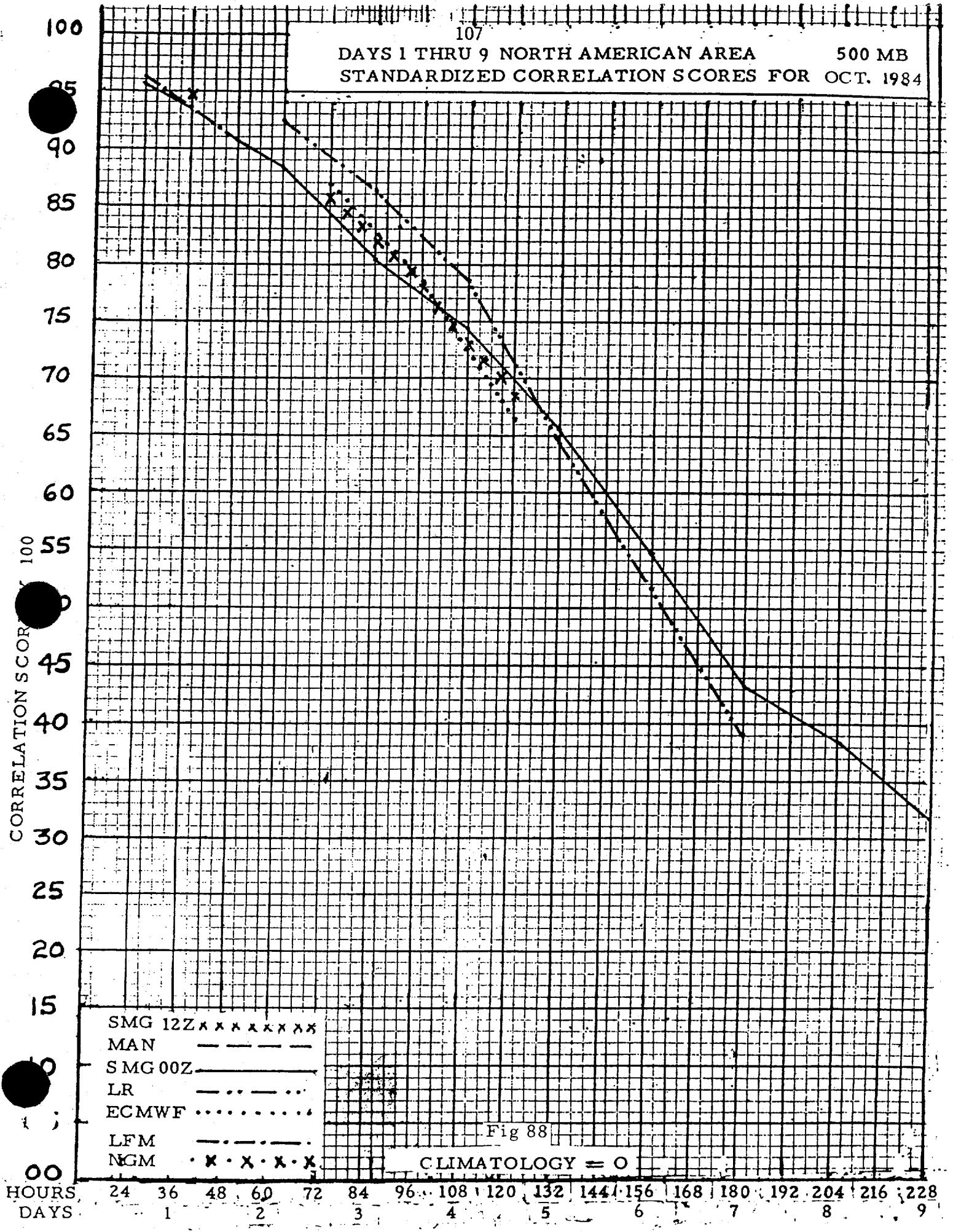
NGM .X.X.X.X

CLIMATOLOGY = O

Fig 86

24 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228  
1 2 3 4 5 6 7 8 9





100

95

85

80

75

70

65

60

55

50

45

40

35

30

25

20

15

10

00

HOURS

DAYS

108

DAYS 1 THRU 9 NORTH AMERICAN AREA  
STANDARDIZED CORRELATION SCORES FOR NOV 84

500 MB

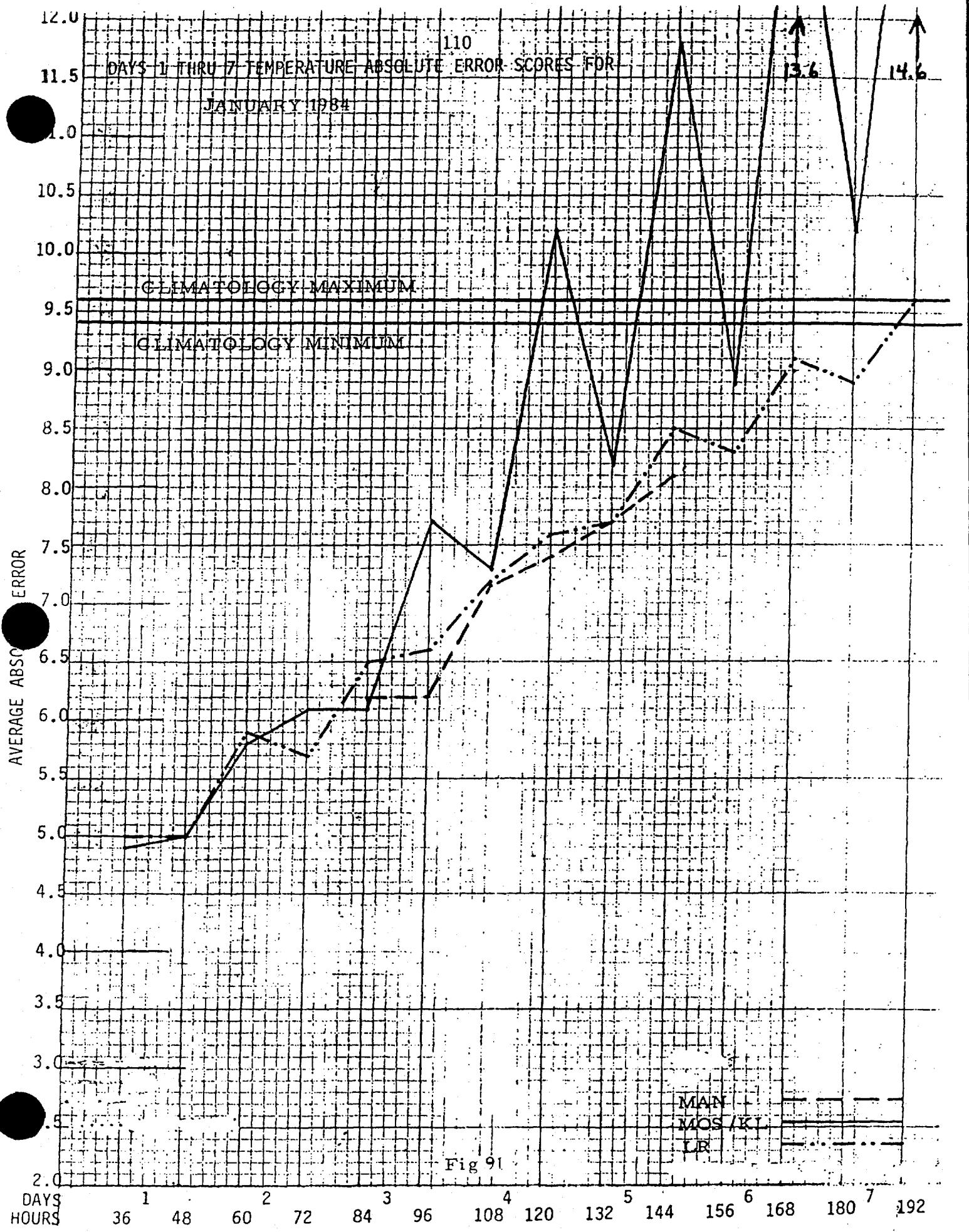
SMG 12Z x x x x x x x x  
 MAN - - - -  
 SMG 00Z - - - -  
 LR - - - - -  
 ECMWF . . . . .  
 LFM - - - - -  
 NGM . x x x x x x

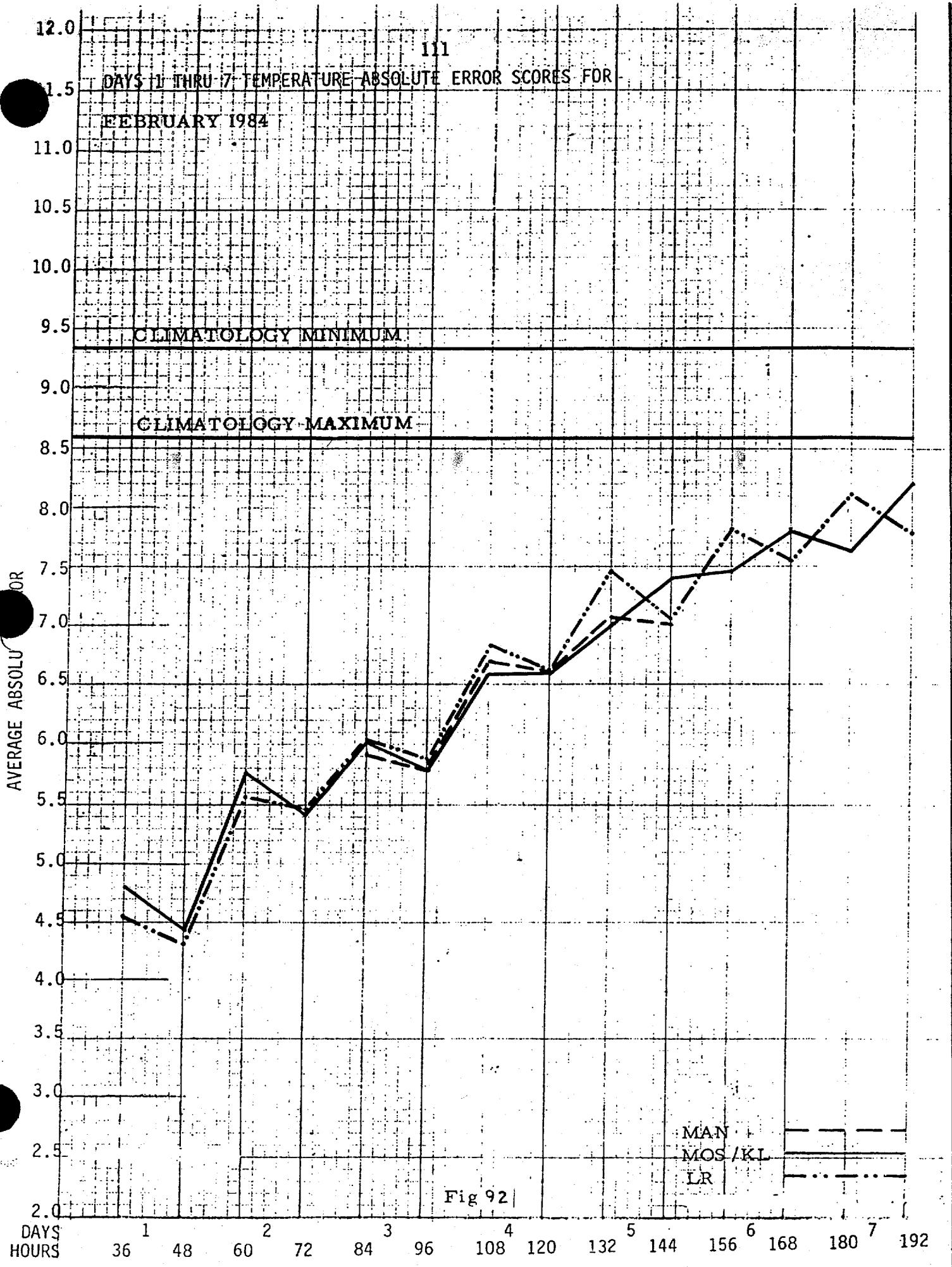
CLIMATOLOGY = 0

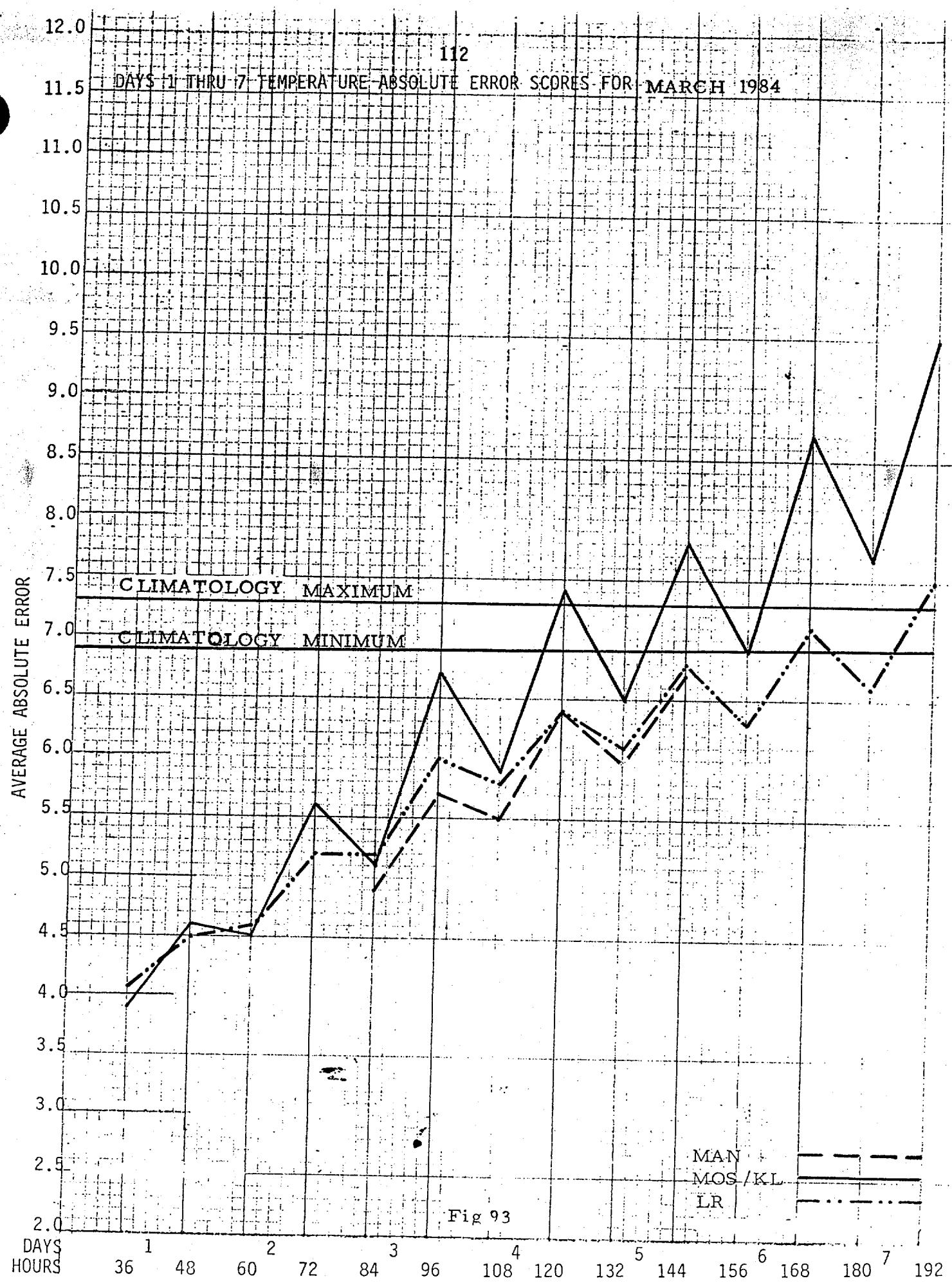
Fig 89

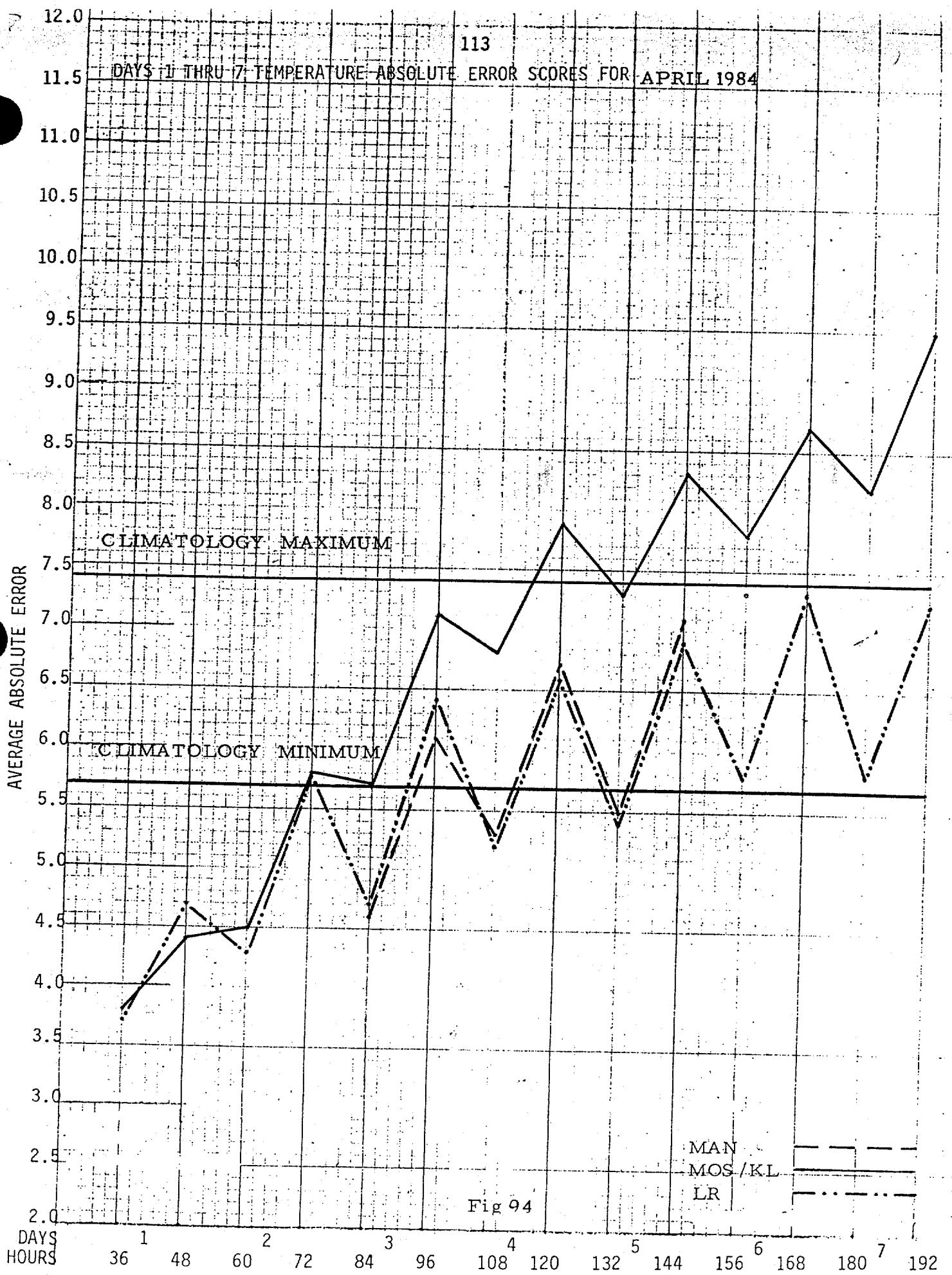
24 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228  
 1 2 3 4 5 6 7 8 9

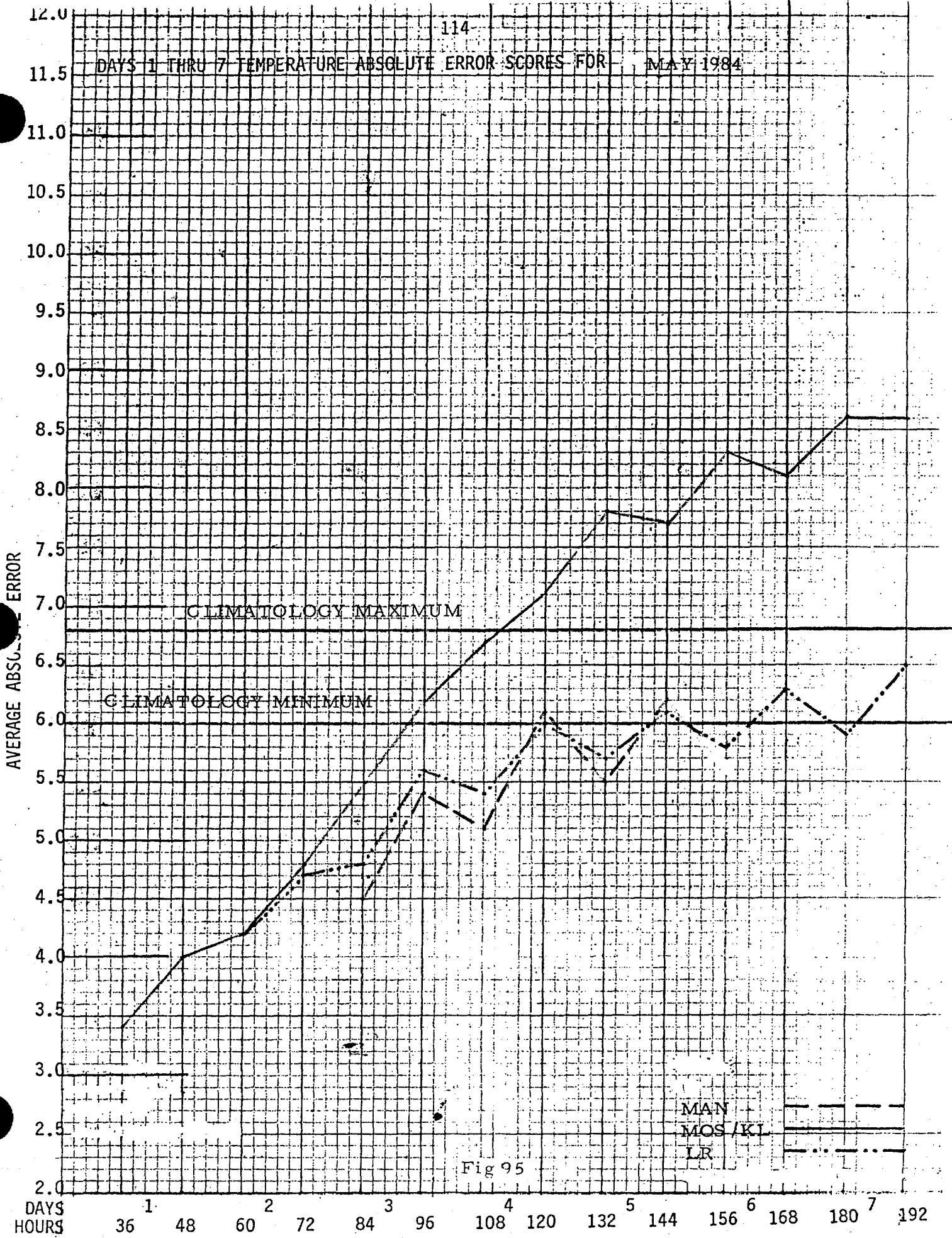


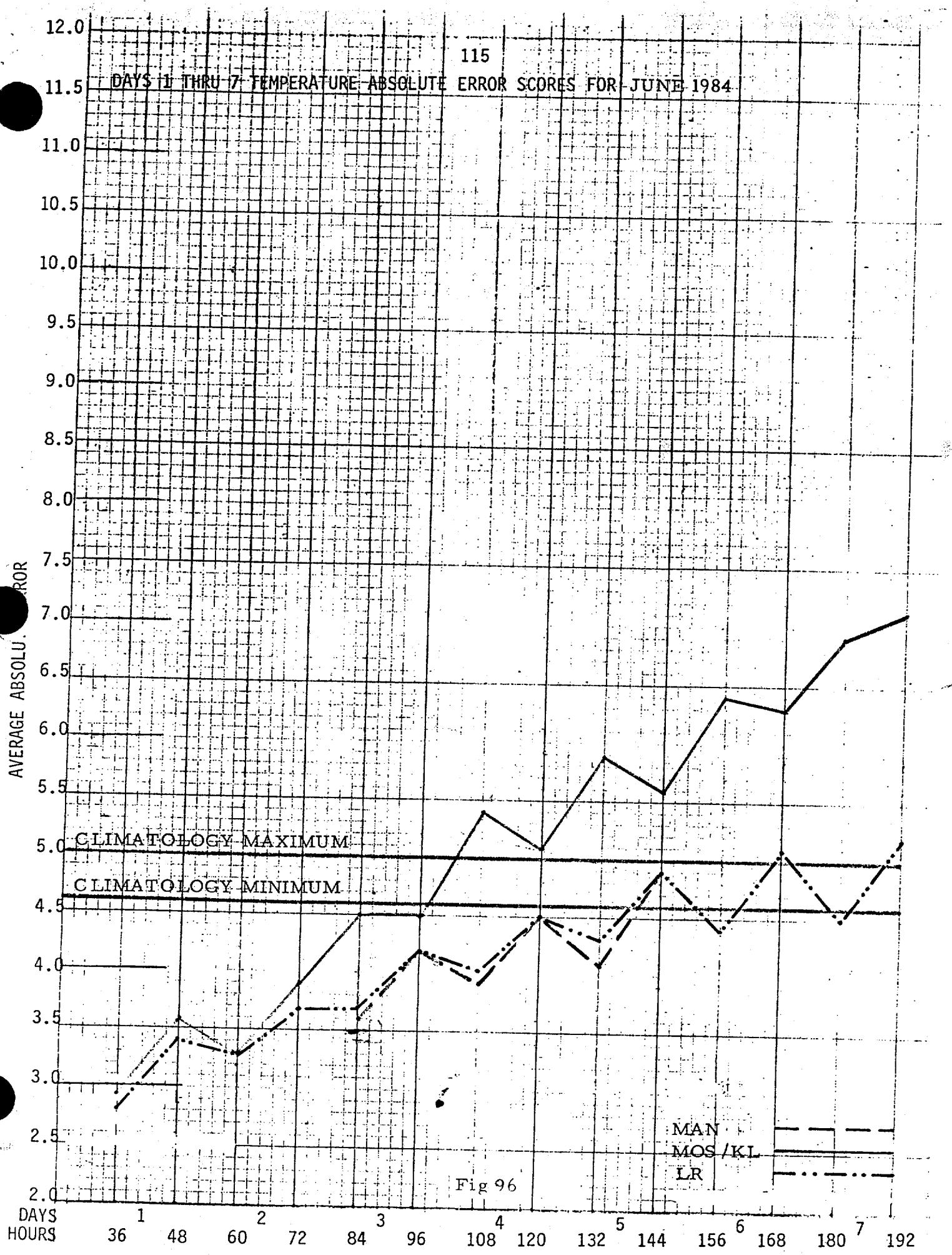


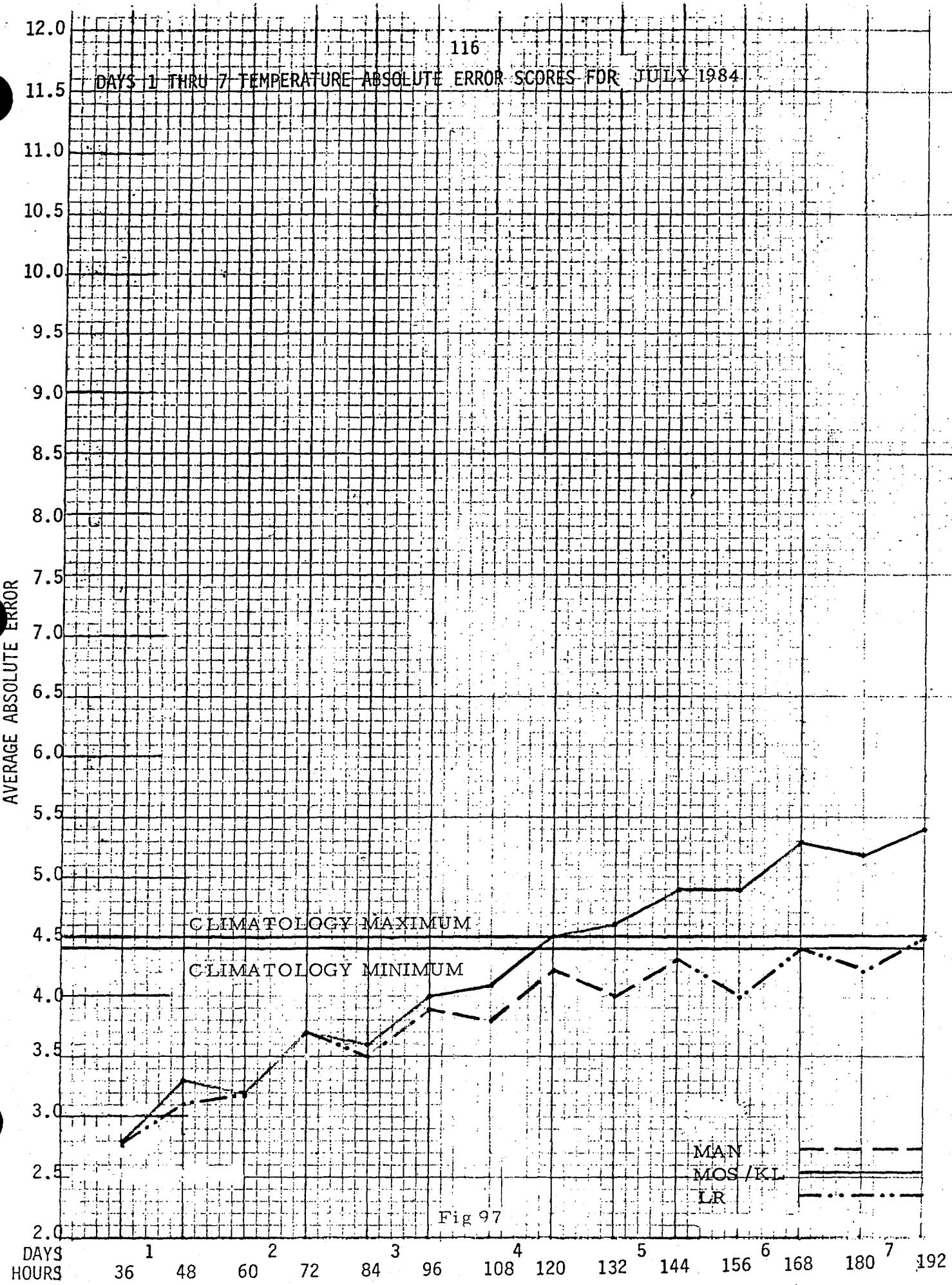


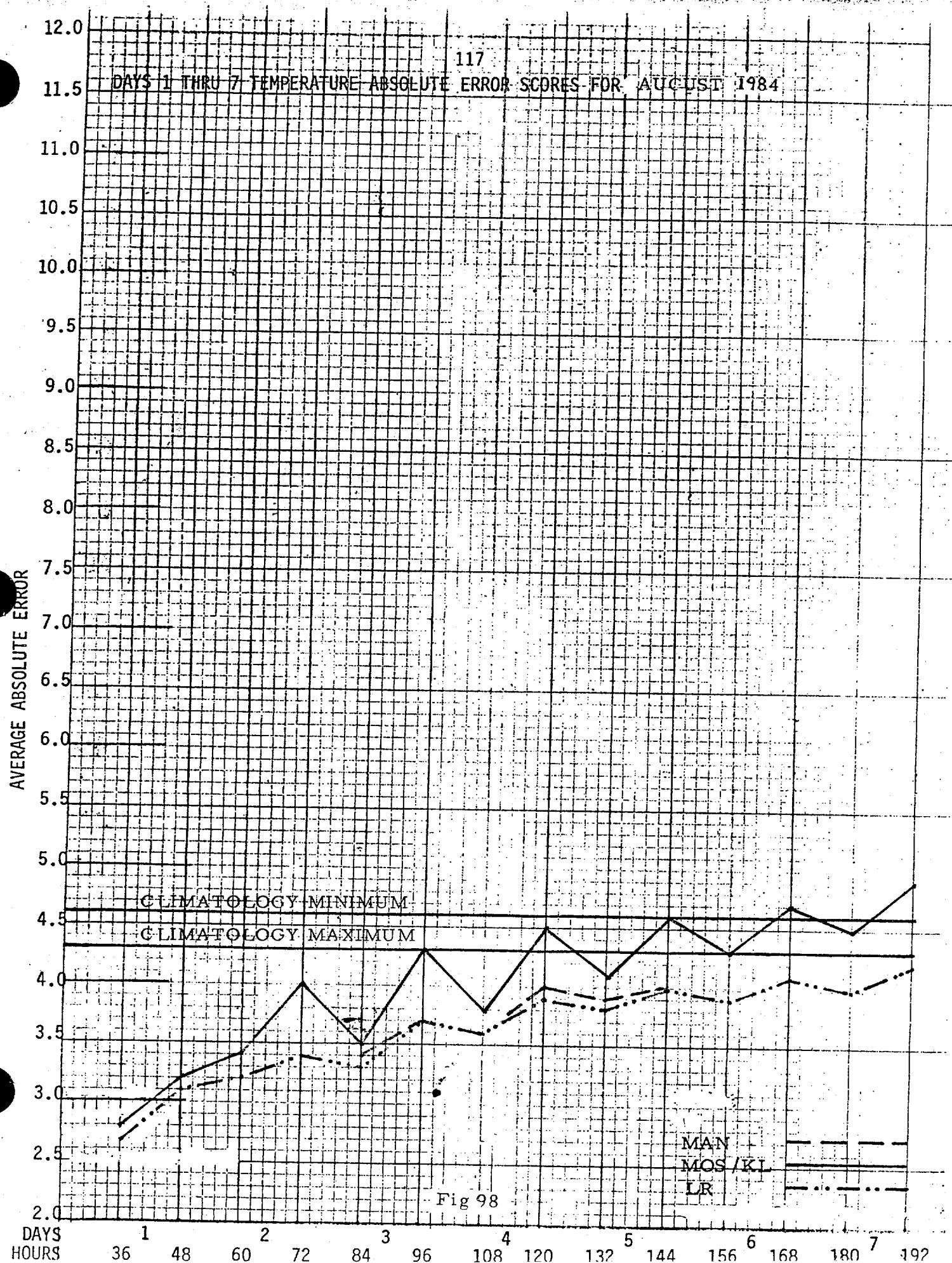


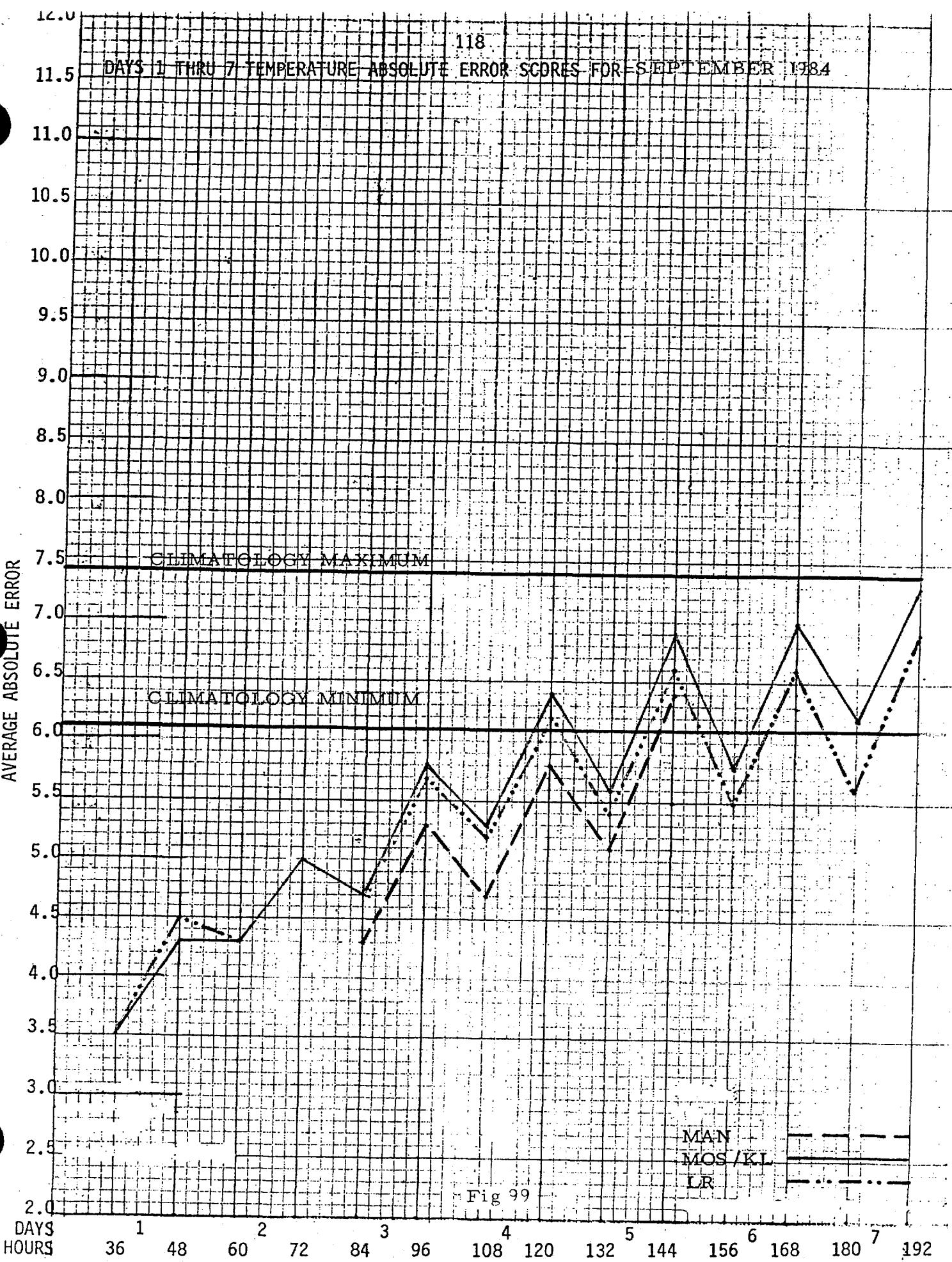








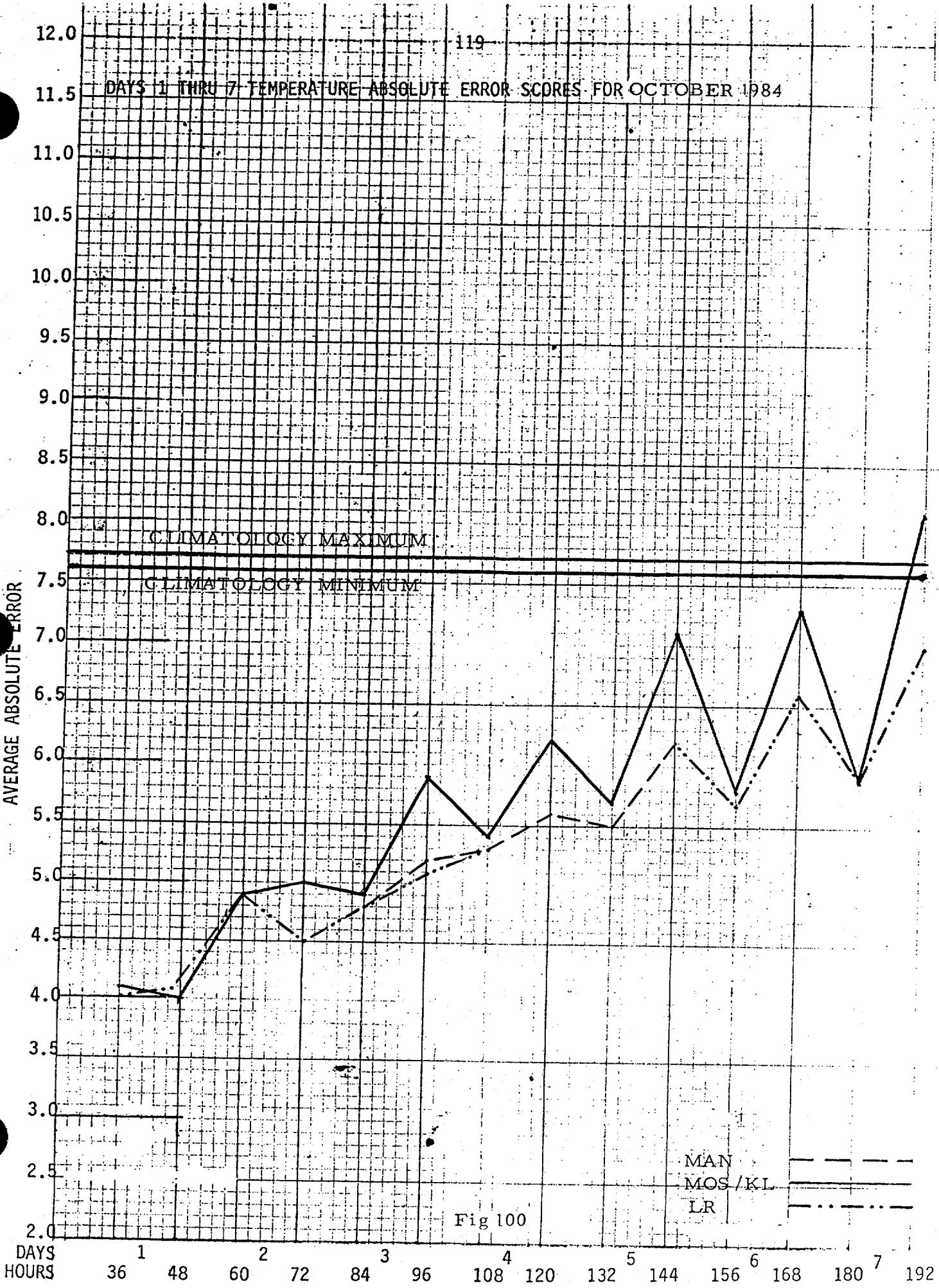


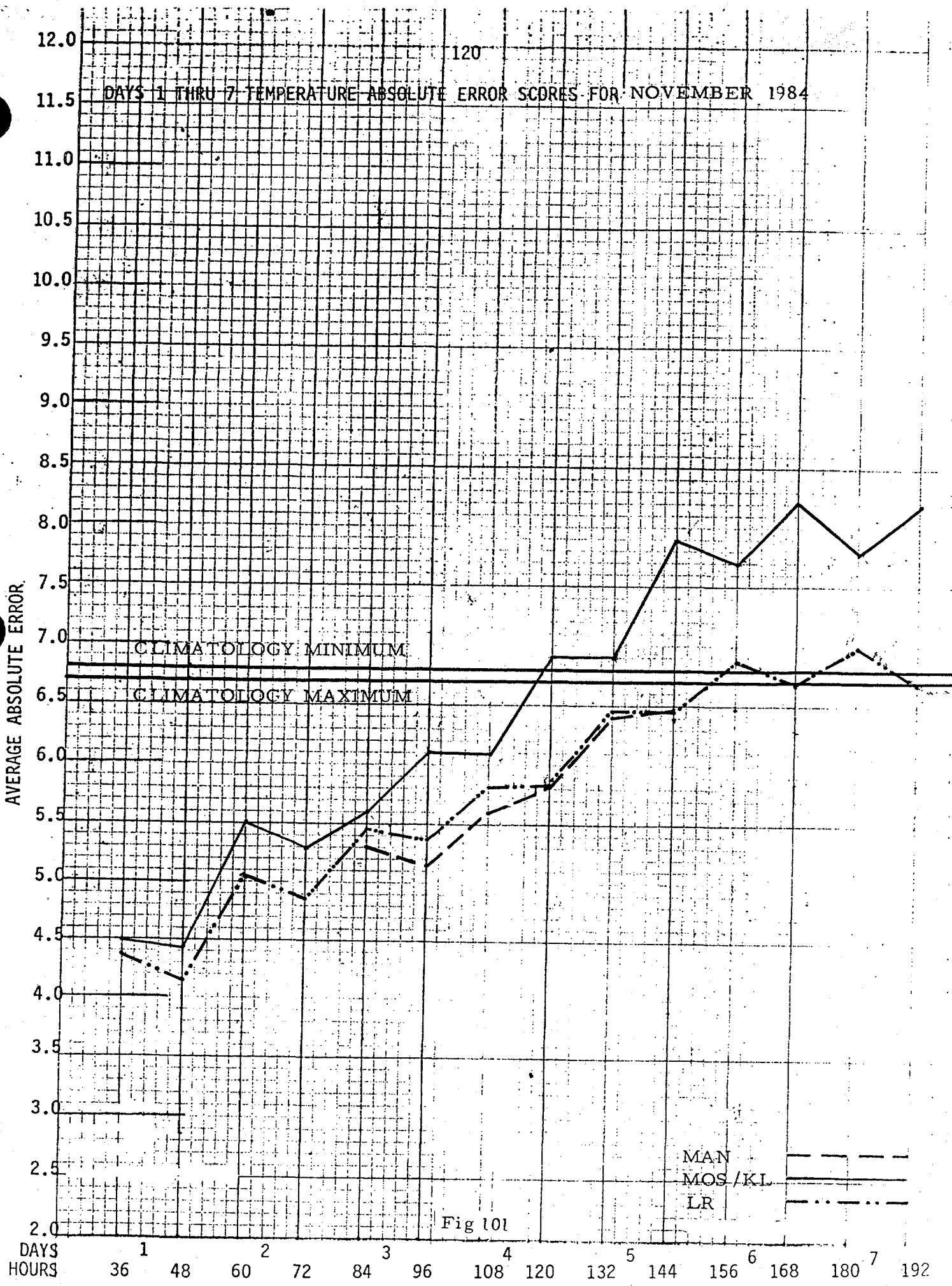


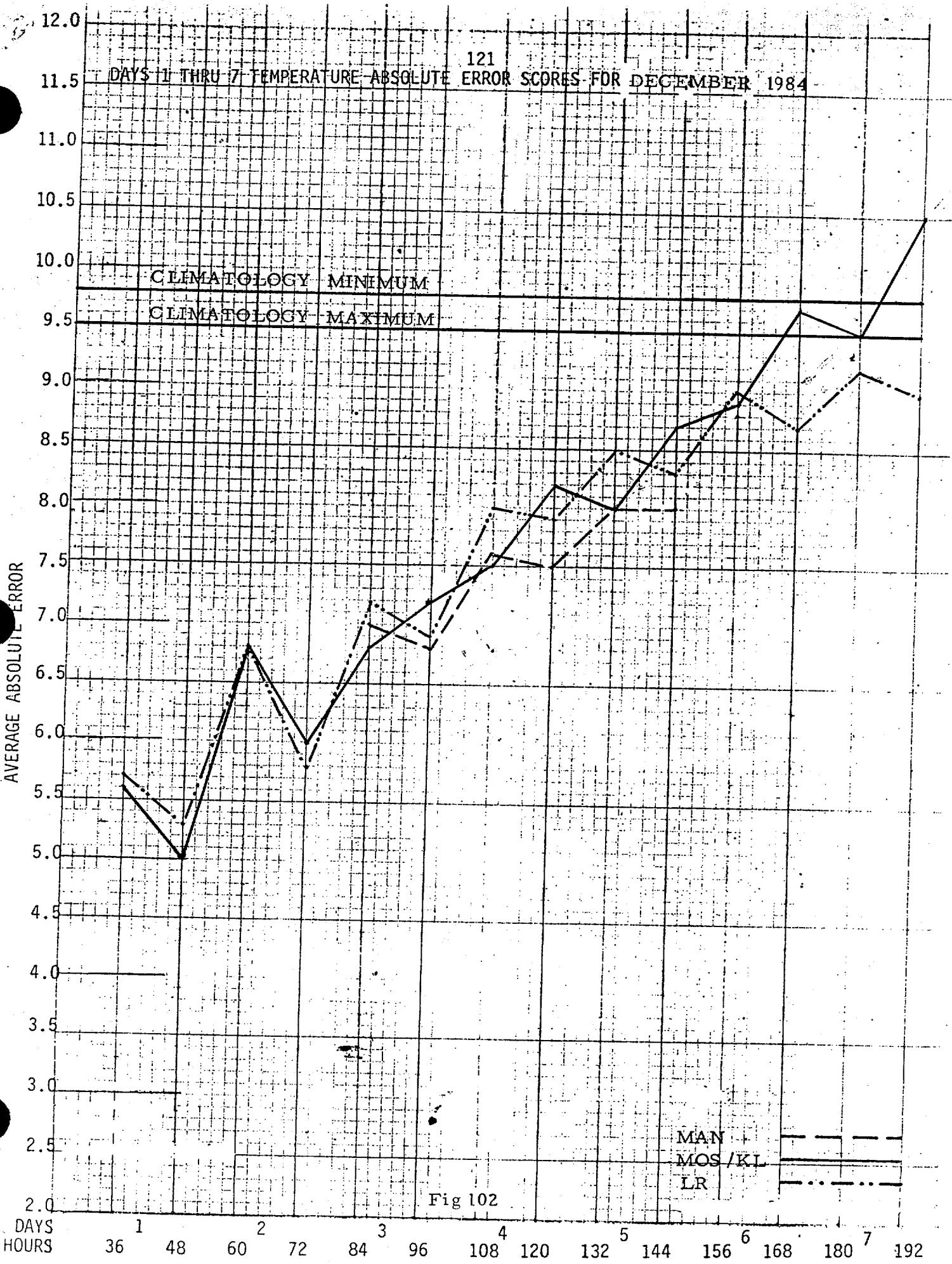
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## DAYS 1 THRU 7 TEMPERATURE ABSOLUTE ERROR SCORES FOR OCTOBER 1984

AVERAGE ABSOLUTE ERROR







COMMENTSSECTION 1 - MSLP & 500-MB CORRELATION SCORES PAGES 10 TO 32

The pattern correlation score (Appendix A) has been the basic score used by the MRFG to verify the MSLP and 500-MB progs since the start of the MRFG program. The correlation score was chosen because it is more sensitive to the phasing of troughs and ridges (considered to be more important) than to the depth or height of these systems. The MSLP and 500-MB operational analyses (HUF) were used to verify the forecast through 1976 and the LFM since 1977.

The North America (NA) standardized correlation score is the oldest score of record. The US subset unfortunately was contaminated from the beginning through 1975 by a coding (program) error affecting the observed field (verifying analysis).

It was assumed from the start that a MSLP standardized (anomalous field) score of greater than 0.0 (climatology) would result in the derived forecasts of temperature and precipitation having more skill than climatology (as a forecast). However, experience has indicated that a NA score of 0.17 or better is required to accomplish this.

Most of the forecasters complained from the beginning about verifying a forecast of the anomalous MSLP field (which they could not "see") instead of the one they produced (the actual MSLP field). In order to appease the forecaster and obtain a score for the normal (climatology) as a forecast the unstandardized (actual MSLP field) score was introduced in 1977 and has been used successfully ever since.

A glance at figures 2 through 22 shows that, for the most part, the monthly mean scores during 1984 were higher (better) than the long term mean scores (note - the long term mean includes the 1984 scores). Also a compari-

son of the current long term mean scores (figures 3,6,9,12,15,18, and 21) with those published in NMC ON 284 of February 1984, indicates an upward trend. The many monthly mean record scores (figures 2,5,8,11,14,17, and 20) set by both the man and NMC/NWP model guidance resulted in 1984 being a near record year for the days 3, 4, and 5 (figures 4,7,10,13,16,18, and 22).

No comment is made concerning the "betterment" of the man over the NMC/NWP model guidance except that it appears to be significant. No overall increase in skill of the guidance in the 1984 was apparent after the introduction of the Optimum Interpolation (OI) Analysis (see page 2). Since the scores for the circulation were near records, one might expect the derived forecasts of temperature and precipitation also to be near record levels.

#### SECTION 2 - TEMPERATURE ABSOLUTE ERROR & SKILL SCORES PAGES 33 TO 47

In 1984, as usual, the bi-monthly mean absolute error minimum (figure 24(a,b,c)) and maximum (figure 27(a,b,c)) temperature scores for the man exhibited a clear superiority over the KL and climatology temperature forecasts for days 3, 4, and 5. The man minimum (figure 26) temperature scores tied the all-time record for day 5 and were second best for days 3 and 4, while the maximum (figure 29) tied the record for days 3 and 4 and was second for day 5.

The man 6 to 10 day 5-class (figure 33) / 3-class (figure 36) temperature skill score was/tied a record in 1984 while the FP scores declined.

#### SECTION 3 - PRECIPITATION SKILL SCORES PAGES 56 TO 73

The Gilman skill score, except for the problem mentioned in Appendix C, is quite sensitive to correct forecasts of precipitation. The Hughes skill score is quite sensitive to correct forecasts of no precipitation at stations with a high climatic precipitation probability. The experimental

score is quite sensitive to correct forecasts of precipitation at stations with a low climatic precipitation probability. Thus, these three scores complement one another.

In 1984, as in recent years, the monthly mean Gilman (figure 39), Hughes (figure 43), and Hughes Probability (figure 46) precipitation skill scores for the man showed a clear superiority over climatology and the NMC/NWP model on days 3, 4, and 5. The man Gilman precipitation skill scores (figure 41) were a record for days 4 and 5 and tied the record for day 3. The Hughes skill (figure 45) and probability (figure 48) scores, however, were not quite so record breaking. The monthly mean 3-class precipitation skill scores for the man 1 to 5 day (figure 51) and 6 to 10 day (figure 54) forecasts were modest in 1984.

SECTION 4 - MSLP, 500-MB & TEMPERATURE SCORES FOR  
DAYS 1 THROUGH 7 PAGES 74 TO 122

Certainly consideration has to be given, after looking at figures 55 through 102, to producing (operationally) for public consumption man MSLP and temperature forecasts for days 6 and 7. It should be noted that for comparison purposes (operational utility) the ECMWF scores have to be "backed down" approximately 12 hours.

CONCLUSION

In retrospect, 1984 turned out to be more of a "high plateau" year than a record breaker for the MRFG. 1985, promises to be an interesting year with the introduction in January, 1985 of the SMG4I with E-2 physics (radiation) and silhouette mountains.

ACKNOWLEDGEMENTS

Thanks to Mrs. Evelyn Seek and Mrs. Donna Thomas for their help with the typing and to Eric McVicker for running off copies.

Appendix A

The standardized mean sea level pressure correlation score is used to determine the skill of the man and machine days 3, 4 and 5 mean sea level pressure forecasts. The correlation score is employed because the phasing instead of the intensity of systems primarily determines how well the various weather parameters can be forecast. The standardizing procedure prevents the contribution of the high variability (higher latitude) grid points from overwhelming the low variability grid points (lower latitude).

$f$  = forecast mean sea level pressure at a grid point

$o$  = observed mean sea level pressure at a grid point

$\sigma$  = standard deviation at a grid point

$n$  = normal mean sea level pressure at a grid point

$$F = \frac{f-n}{\sigma} \quad o = \frac{o-n}{\sigma}$$

$\bar{F}$  = average standardized forecast across  $n$  grid points

$\bar{o}$  = average standardized observed across  $n$  grid points

$$\text{RMS } F = \sqrt{\frac{F^2}{n}} \quad \text{RMS } o = \sqrt{\frac{o^2}{n}}$$

$$\text{RMS Error} = \sqrt{\frac{(F-\bar{F})^2}{n}}$$

$$\text{Average Absolute Error} = \frac{1}{n} \sum |F_i - \bar{F}|$$

$$\text{Correlation} = \frac{\bar{F}o - \bar{F}\bar{o}}{\sqrt{(\bar{F}^2 - \bar{F}^2)(\bar{o}^2 - \bar{o}^2)}} \times 100$$

Since the normal mean sea level pressure is subtracted from the forecast/observed pressure at each grid point, it is assumed that the correlation of the normal to the observed is always zero. Therefore, any positive score is considered

to have skill over the normal. Some doubts have been raised about this assumption, however, and for the past 5 years the unstandardized correlation score also has been calculated. This procedure allows a correlation score to be computed for the normal. This score then is simply the correlation of the forecast to the observed mean sea level pressure.

APPENDIX B

The 5 day mean temperature skill score is a generalization of the Heidke skill score where the expected values are derived from the observed temperature

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)  
N = total number of forecasts (61)  
E = expected number of hits

The expected value is calculated as follows from the number of stations in each of the observed temperature categories:

$$E = 1/8 \times \text{Much Below} + 1/8 \times \text{Much Above} + \\ 1/4 \times \text{Below} + 1/4 \times \text{Above} + 1/4 \times \text{Normal}$$

The 5 day mean 3 class temperature skill score simply "lumps" together the much below with the below and the much above with the above. The expected (E) then is equal to  $1/4 \times \text{Below} + 1/4 \times \text{Normal} + 1/4 \times \text{Above}$ .

Appendix C

The Gilman skill score is a generalization of the Heidke skill score where the expected values are derived from a randomized version of the precipitation forecast.

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)

N = total number of forecasts (100)

E = expected number of hits

However, for a randomized forecast allowance must be made for stations having far different precipitation climate (N POP) across the United States. Therefore, to compute and score an expected chance forecast, climatology must be considered.

The procedure for this is as follows:

First, the actual number of forecasts of precipitation are distributed randomly taking into account station climatology. The expected number of chance hits is then given by:

$$E = \sum_{i=1}^N (p_i r_i + (1 - p_i)(1 - r_i)) \text{ or}$$

$$E = 2 \sum_{i=1}^N p_i r_i + N - \sum_{i=1}^N p_i - \sum_{i=1}^N r_i \quad (a)$$

where  $r_i = 1$  for precipitation ( $\geq 0.01$  inch) and 0 for no precipitation ( $< 0.01$  inch).

Now an expression for  $p_i$ , which is the probability that after the forecast precipitation events are redistributed randomly a forecast precipitation event will fall at point "i" is given approximately by  $p_i = \frac{F}{N} \frac{a_i}{\sum a_i}$  (b). Here F = total number of forecasted precipitation events and  $a_i$  = climatic precipitation probability (N POP). This approximate value for  $p_i$  is most valid for small values of F and ( $a_i / \sum a_i$ ) and is unstable at times. Because of this instability the less sophisticated but more stable Hughes skill score was developed.

Substituting the expression (b) into (a) gives  $E = \frac{N}{\sum a_i} + N - F - R$ , where  
 $E$  = the approximate expected value of a randomized forecast,  $R$  = total precipitation cases, and  $N$  = total number of stations. If the climatic probabilities are uniform ( $a_1 = a_2 = \dots = a$ ), then the approximate value of E reduces to the standard Heidke value given by:  $E = \frac{(N-F)(N-R)+FR}{N}$ .

Appendix D

The Hughes skill score is a generalization of the Heidke skill score where the expected values are derived from the observed precipitation:

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)

N = total number of forecasts (100)

E = expected number of hits

If the average precipitation climate (NPOP) of 12 stations having precipitation is 25, then the expected (precipitation) is simply  $12 \times .25$  or 3 stations.

If the average NPOP of the (100-12) stations not having precipitation is also 25 then the expected (no precipitation) is simply  $88 \times (1.0-.25)$  or 66 stations.

The total expected (E) then is 69 stations. If the forecaster hit (C) 75 stations correctly, his skill score then is  $(75-69)/(100-69) \times 100$  or 19.

APPENDIX E

The (Hughes) probability score is not a skill score yet it is quite simple to understand. A rough score (RS) is calculated for each station ( $N=1$  to  $100$ ) as follows:

<u>Forecast</u>	<u>Observed</u>	<u>RS</u>
$(DN \text{ POP} + NPOP) \geq 30$	$P=1$	$+(1 - NPOP)$
$(DN \text{ POP} + NPOP) \geq 30$	$P=0$ and $NPOP \geq 50$	$-(NPOP)$
$(DN \text{ POP} + NPOP) < 30$	$P=1$ and $NPOP \geq 50$	$-(NPOP)$
$(DN \text{ POP} + NPOP) \geq 30$	$P=0$ and $NPOP < 50$	$-(1 - NPOP)$
$(DN \text{ POP} + NPOP) < 30$	$P=1$ and $NPOP < 50$	$-(1 - NPOP)$
$(DN \text{ POP} + NPOP) < 30$	$P=0$	$+(NPOP)$

Since the total rough score (TRS) for the 100 stations does not equal 100 points, a simple iterative technique is employed which uses the RS as a  $f(NPOP)$  for each station to bring the total number of points up to 100.

The FORTRAN language routine is:

```

    TTY = 0
70    DO 69  I = 1, 100
       TRS = (100.0 - TRS) * ABS(RS(I)) * .01
       IF(RS(I)) 73, 74, 74
73    RS(I) = RS(I) - TRS
       GO TO 69
74    RS(I) = RS(I) + TRS
69    TTY = TTY + ABS(RS(I))
       TRS = TTY
       TTY = 0.0
       IF (TRS - 99.8) 70, 71, 71
71    CONTINUE

```

APPENDIX F

The 5-Day mean precipitation skill score is a generalization of the Heidke skill score where the expected values are derived from the observed precipitation:

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)

N = total number of forecasts (100)

E = expected number of hits

For example, in January the number of stations in the area covered by the (NP/P), (NP/M/H) and (L/M/H) categories is 21, 28 and 51 respectively. The average value of the probability of NP for the stations in the (NP/P) area is 59% and 40% in the (NP/M/H) area. Now if (NP/L) is coded as 1, M as 2 and (P/H) as 3, then the number of stations expected to have coded value 1 thru 3 is as follows:

$$33\% \text{ of } (L/M/H) = 51 \times .33 = 17 \text{ stations coded 1, 2, 3}$$

$$40\% \text{ of } (NP/M/H) = 28 \times .40 = 11 \text{ stations coded as 1 and } 8.5 \text{ coded as 2,3}$$

$$59\% \text{ of } (NP/P) = 21 \times .59 = 12 \text{ stations coded as 1 and } 9 \text{ coded as 3}$$

$$\text{Thus, code 1} = 17 + 11 + 12 = 40 \text{ stations}$$

$$\text{code 2} = 17 + 8.5 = 25.5 \text{ stations}$$

$$\text{code 3} = 17 + 8.5 + 9 = 34.5 \text{ stations}$$

$$100.0 \text{ stations}$$

Therefore, the expected value = .40a + .255b + .345c

where a, b and c are the number of coded values 1, 2 and 3 observed.

